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PSYCHOLOGICAL RESEARCH ON FLEXIBLE GUNNERY TRAINING

Nicholas Hobbs

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Edited by
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Preface

This report is a summary and synthesis of the work of aviation psychologists in the flexible gunnery program of the Army Air Forces. An attempt has been made to describe research techniques and results to the end that ready transfer to other problems in applied psychology may be obtained. The reporting of historical materials is limited to an account of such instances and circumstances as will aid in understanding the research done. One of the most significant of these circumstances is that the work here reported was a part of a cooperative research program in which other professional groups participated. The contribution of those other groups to the work described in this report was substantial. A complete account of gunnery research would more adequately recognize their contribution to better gunnery, and would, in addition, give evidence of the effectiveness of research when men of varied interests and special qualifications cooperate in seeking solutions to a complex problem. The reader who is interested in obtaining an overview of the materials reported in detail in appropriate chapters is referred to chapter 15, which summarizes the total report and provides a brief evaluation of the work done.

Through encouragement, counsel, and other assistance many individuals have contributed to psychological research in gunnery. Notable among those are several leaders in gunnery training who gave support to research in the initial stages of the program, when support was most needed. Col. Delmar T. Spivey, Col. Daniel W. Jenkins, Col. William L. Kennedy, Col. Leland S. Stranathan, the late Col. Richard R. Waugh, and Lt. Col. Elmer A. Dittmar should be mentioned. The expansion of psychological research and the development of the cooperative research program mentioned above reflect the interest in research of Brig. Gen. Edwin B. Lyon and Col. E. M. Day. Lt. Col. Ernest R. Manierre facilitated the preparation of this report by making available personnel and file materials. Numerous officers and enlisted men in gunnery training worked with intelligence and industry to assure the success of day-to-day operations.

Within the Aviation Psychology Program, Col. John C. Flanagan and Col. Frank A. Geldard should be mentioned for their guidance and support. Appreciation is expressed to Maj. Neal E. Miller, Director of the Psychological Research Project (Pilot), for

many courtesies, and for providing a haven for the writing of this report.

Several civilian psychologists deserve a special word of appreciation for advising on specific problems. Dr. Carl R. Rogers, Dr. Charles W. Bray, Dr. W. J. Brogden, Dr. K. U. Smith, and Dr. L. L. Thurstone are prominent among these.

Prof. John Russell, Dr. Hugh Wolfe, and Dr. Edgar Dale gave valuable assistance on problems related to their special fields.

Maj. Roger W. Russell, Maj. John V. McQuitty, and Maj. Robert Bragarnick contributed much to the planning of the gunnery research program. The importance of Major McQuitty's contribution, in particular, is not fully evident in the assignment of credits for special projects. The complexity of the gunnery research program makes it difficult to designate with accuracy, in every instance, those who should be given specific recognition for work on various projects.

The officers who assisted in the preparation of this report did so at some personal inconvenience. Two of the officers devoted several months of Army service beyond that required of them, in order to make the report possible. Lt. William B. Schrader deserves special mention for valuable counsel on technical problems and for editorial work on the entire report.

NICHOLAS HOBBS
Lt. Col., A. C.

Randolph Field, Tex., 1 March 1946.

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CHAPTER ONE

A Brief History of the Flexible Gunnery Program

Maj. Nicholas Hobbs

INTRODUCTION

The Scope of the Report

This is a report of psychological research in flexible gunnery. Since less is known about the gunner and about gunnery than is known about the pilot, the bombardier, the navigator, and their jobs, the first section of the report will tell about the enlisted members of the combat crew and the job they had to do. The history of gunnery, of gunnery training, and of gunnery research will be surveyed; something will be said about the gunner's job; the gunner himself will be described; and the function of psychological research in gunnery will be indicated. Against this background of information, there will be presented in subsequent sections of the report an account of a research program, the goal of which was to put well-selected and well-trained gunners into bomber crews, gunners who could help defend a formation from the attacks of enemy fighters and thus make possible the effective bombing of enemy industrial and military installations.

EARLY FLEXIBLE GUNNERY (1917 to 1942)

Gunnery Before Pearl Harbor

Flexible gunnery started in World War I. In the latter period of the war, bombers mounted flexible caliber .30 machine guns, for which simple mechanical sights were invented. In the years between World War I and World War II, bombers grew up, and gunnery equipment grew up with them. The rugged caliber .50 machine gun appeared, turrets of sturdy design and easy control were developed, and a fairly adequate computing sight became standard equipment for some gun positions. But knowledge of gunnery remained meager, and interest in the problems of gunnery

was dormant. Anecdote has it that gunnery training, in the intervening years of peace, consisted of an annual shoot during which a few hundred rounds of ammunition were fired at clouds, or occasionally at a sleeve-type target towed by another airplane. When war came again, we knew relatively little about flexible gunnery.

The British had learned something about gunnery, the hard way, during the early days of the war when their bombers fought the aggressive Luftwaffe fighters. We learned first from the British. In the summer of 1941, several officers of the Army Air Forces were sent to England to learn all they could about flexible gunnery, and on their return they were charged with setting up a program for the training of gunners. The first basic flexible gunnery school was opened at Las Vegas Army Field on 22 December 1941. In quick succession, schools were opened at Tyndall Army Air Field, Fla.; at Harlingen Army Air Field, Tex., and, later, at Buckingham Army Air Field, Fla, and Laredo Army Air Field, Tex. Every effort was made to set up quickly a training program that would send gunners into combat well prepared to do their jobs.[1]

Combat Gunnery, Early Period

What aerial combat was like in the early days of the war will be remembered from newspaper stories in which figured such names as Rabaul, Tarawa, Emden, Paris, Wilhelmshaven. Nearly all of the bombers (B-17's, B-18's, B-24's, B-25's, and B-26's) had one or more turrets, but hand-held guns, equipped with crude iron ring-and-post sights, predominated. Only the Flying Fortress was equipped, in two positions, with computing sights. Combat conditions were perilous. In the Pacific, on return from a day-long mission, gunners cleaned their guns in the dark, for a flicker of light would have brought the whine of a sniper's bullet. In the European Theater AAF bomber losses were great. The German Air Force was converting to fighters, and our bomber formations were met by hordes of ME-109's and FW-190's, flown by competent pilots. The newspaper stories of that period were not encouraging.

[1] For simplicity, the gunnery schools will be referred to as Las Vegas, Kingman, Yuma, Laredo, Harlingen, Tyndall, and Buckingham, although the official designation of a gunnery school was, for example, "Army Air Forces Flexible Gunnery School, Las Vegas Army Air Field, Nevada." The AAF Instructors School (Flexible Gunnery), located at Buckingham Army Air Field, Fla., will be referred to as the Instructors School, and its successor, The Central School for Flexible Gunnery, located first at Buckingham and later at Laredo, Tex., will be designated by the initials CSFG or by the commonly used expression "the Central School." The terms "Instructors School" or "Instructors Course" also refer to the instructor training activity of the Central School.

Gunnery Training, Early Period

Training of gunners for combat left much to be desired. The curriculum in those early days expressed the ingenuity of a group of officers and enlisted instructors, who had little precedent and no organized body of knowledge to guide them. Lesson plans on the machine gun were based on infantry manuals, aircraft recognition courses were based on British materials, turret courses were drawn from texts supplied by turret manufacturers, and no adequate sighting course existed. There was insufficient equipment. Caliber .30 machine guns were substituted for the scarce caliber .50 gun. Each school had only a few turrets to use for demonstration purposes. Gaps were filled in by almost any kind of activity, particularly shooting, which might teach a gunner something that would help him handle a gun in combat. The first moving-target range for machine gun firing consisted of a cloth target, mounted on a sled, which was tied by a long rope to a truck and towed across the desert, to be fired at to the presumed profit of the student and the unquestionable discomfort of the driver. Civilian skeet champions were commissioned and assigned to the program, and shotgun shooting became an important part of training gunners to shoot caliber .50 machine guns from a 225-mile per hour bomber at a 325-mile per hour fighter. Gadgets with simulated machine guns to be fired at airplanes mounting photo-electric cells were garnered from amusement parlors and put into service. Compressed air guns shooting B–B shot or small sized pellets were developed for indoor ranges, and attempts were made to develop quickly a caliber .22 machine gun for outdoor firing. For air training, caliber .30 machine guns were mounted in the rear cockpit of small, two-place airplanes, to be fired by the gunner at a sleeve target towed by another plane. The gunnery training program was weak; it needed a lot of improvement. No one realized this better than the men who were charged with making it better. A long step was taken toward better gunnery, when, in December 1942, the AAF Instructors School (Flexible Gunnery) was established to train instructors, to standardize basic training, and to provide personnel and facilities for research.

Gunnery Research, Early Period

Psychologists became interested in gunnery in late 1942. In September of that year, three small research detachments (one from each of the Psychological Research Units active at that time) were sent to the gunnery schools at Las Vegas, Harlingen, and Tyndall, for the purpose of assisting in the selection of gunnery students to receive further training as low-altitude bombardiers.[2]

[2] See Appendix A,1 for names of psychologists in gunnery.

The detachments also were directed to explore the possibility of developing a battery of tests to be used in the initial selection of men for gunnery training. A total of 62 aptitude tests were administered to determine their appropriateness for use in a gunnery selection battery, but attempts to validate these tests against criteria of gunnery proficiency in training gave disappointing results. No generally adequate and dependable criteria could be found. The records of class after class on air-firing and on machine-gun firing on ground ranges were checked for reliability. The reliability of all measures of performance critical for gunnery clustered around zero, and there was little evidence that gunners were learning to aim and fire a machine gun. The results of these exploratory investigations were presented to the officers in charge of gunnery at a conference in Fort Worth in January 1943. Impressed by the findings, these officers requested that a group of psychologists be assigned to the gunnery program to continue the research which had been initiated on the selection and training of gunners. In March 1943, Psychological Research Detachment (Gunnery), staffed by two officers and eight enlisted men, was activated and attached to the Instructors School.

GUNNERY IN THE MIDDLE PERIOD (1943-1944)

Combat Gunnery, Middle Period

Leaders of combat air forces were becoming worried about the defense of bombers. The reader will remember newspaper accounts of bombing missions over Germany in 1943 and early 1944, when our bombers were penetrating deep into German territory against relentless opposition. Stuttgart, Saarbrucken, Munster, Gelsenkirchen, Brunswick, Schweinfurt were familiar names. And accounts of losses stick in the memory, too: "28 B-17's lost," "45 down," "60," "80," "84," on a single mission. Fighter escort was introduced in the European Theater; improved gunnery equipment was installed; but losses were still heavy. Urgent requests for better trained gunners were made by combat commanders.

It was recognized by training officers that gunnery training was not related closely enough to the gunner's job in combat. To remedy this deficiency, 18 key officers from the gunnery program were sent to the European Theater in June of 1943 to observe combat gunnery in the 8th Air Force and to make recommendations for revision of gunnery training in the States. Though much valuable information was obtained, and later put to good use, the outcome of the mission was tragic. In spite of every precaution to reduce chances of losses, six of the most important men in gunnery training were shot down. This event gave per-

sonal meaning to statistics on bombers lost, and underscored the urgent need for better gunnery training.

Gunnery Training, Middle Period

Much was done during this period to improve gunnery training. Four-engine bombers were assigned to the basic schools to give gunners training on the type of equipment they would use in combat. A new system of sighting, called Position Firing, was developed and adopted as standard in September of 1943. The gun camera was introduced into the training program to check students' ability to apply sighting rules in the air, against attacking pursuit planes. Several synthetic trainers were installed at all gunnery schools. And two additional schools were opened, at Kingman Army Air Field, Arizona, and Yuma Army Air Field, Ariz.

Something of the complexity of the problem of gunnery training, and of the lack of structure in the training program, is suggested by figures on training devices and procedures. At least 14 different types of indoor synthetic trainers were built in an attempt to train gunners in sighting; 16 types of outdoor ranges were constructed and used at one time or another; 5 distinct types of air missions were devised, with many modifications; and the number of gadgets, devices, and ranges that were proposed but never adopted was legion. These facts are eloquent tribute to the ingenuity and enthusiasm of the men concerned with gunnery training; they are also eloquent testimony that a random trial-with-no-correction-of-error method of training gunners prevailed.

Gunnery Research, Middle Period

Psychological research in gunnery, to be described in detail in the main body of this report, assisted during this period in the establishment of an instructor-selection program, the development and standardization of examinations for all gunnery schools, the development of a new type of performance test known in gunnery as a phase check, the evaluation of trainers and the devising of techniques for the use of training devices, the publication of tests for the selection of gunners, and the revision of methods of training in accordance with established principles of learning. There was more work to be done than could be done by the small group of psychologists originally detailed to gunnery research. On 1 May 1943, a conference of gunnery officials recommended that the number of psychologists assigned to gunnery research be increased and that provisions be made for a permanent psychological research unit in gunnery. In response to this recommendation, additional psychologists were added to the original group, and, on

1 October 1943, Psychological Research Unit No. 11 (Gunnery) was activated, with a table of organization calling for 11 officers and 43 enlisted men.

There was recognized at this time a need for better supervision and training of gunners in the combat air forces. Gunnery proficiency had to be maintained, and gunners had to be trained in the theater to use new equipment and new techniques. The answer to this problem seemed to be to provide specially trained gunnery officers for assignment to each combat organization to which gunners were assigned. In January 1943, an officer from Psychological Research Unit No. 11 was sent on a mission to England to study the requirements of the 8th Air Force for gunnery officers and to learn from the Royal Air Force their concept of the function of the commissioned Gunnery Leader. A job description for the gunnery officer was accomplished, and, on the basis of this investigation, recommendations for the selection and training of gunnery officers were made.

Training Plans, Middle Period

What has been rather arbitrarily called the middle period in gunnery culminated in a conference held at 3rd Air Force, Tampa, Florida, on 12-14 April 1944. The chief significance of this conference was the proposal by Brigadier General E. B. Lyon that the Central School for Flexible Gunnery be established as the "fountain-head of knowledge" on flexible gunnery, with an expanded program for the training of gunnery instructors and of rated gunnery officers. Increased personnel and facilities for research in gunnery and for liaison between the Central School and all air forces would be provided for. This recommendation was later approved and the decision made to locate the Central School on a separate base at Laredo Army Air Field, where a small experimental school for the training of basic gunners could also be operated as a part of the Central School.

The organization of the proposed Central School for Flexible Gunnery was illustrated at the Tampa Conference by the chart shown in figure 1.1. Though there were to be changes in the organizational plan, the essential features of the Tampa proposal remained intact—a single gunnery training system with six basic gunnery schools, and with a central school responsible for the training of instructors, the training of gunnery officers, the operation of an experimental basic school, the development of training materials, the conduct of research, and the establishment of liaison with all groups concerned with gunnery training. The most significant subsequent changes in organization, not shown on the above chart, were three. First, the single gunnery wing was

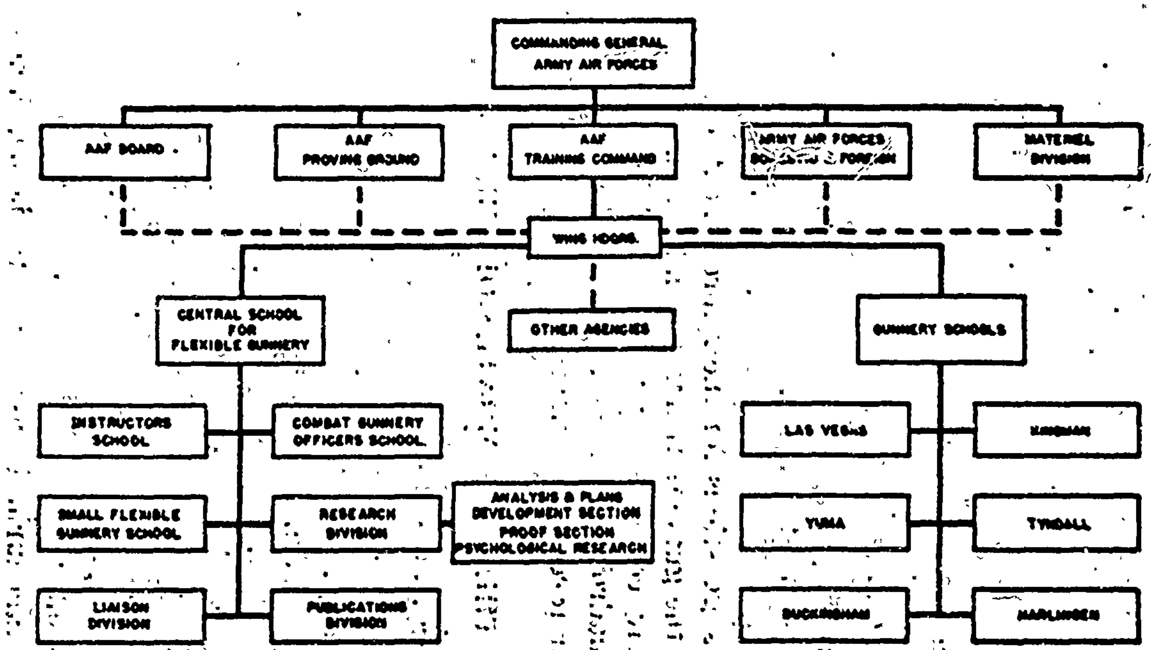

FIG. 1.1 — PROPOSED ORGANIZATION OF FLEXIBLE GUNNERY TRAINING PROGRAM PRESENTED AT TAMPA GUNNERY CONFERENCE (APRIL 1944) AND SUBSEQUENTLY ADOPTED WITH MINOR MODIFICATIONS.

supplanted by the office of the Deputy for Flexible Gunnery Training, a special staff position set up by the Commanding General of AAF Training Command to assure that gunnery training got the attention that was desired. Second, the Publication Division was made a part of the Research Division. Third, a local director was provided for the two functions of liaison and research.

During the 5 months following the Tampa Conference, the Central School was moved to Laredo (in June 1944), and there followed a period of productive activity. The Gunners Information File, generally recognized as one of the best of the Army Air Forces' training manuals, was published. A new series of phase checks was printed and distributed to all schools and air forces. The training of gunnery officers proceeded apace, and research activities expanded rapidly. At this time, attention was again turned to the combat gunner as a source of information on the adequacies and weaknesses of gunnery training. Three psychologists were dispatched to the 7th Air Force, to the 5th and 13th Air Forces, and to the China-Burma-India Theater to obtain objective measures of the proficiency of gunners in combat zones, and to obtain suggestions for the improvement of the training of gunners from the gunners themselves and from officers who were most intimately concerned with the ability of the gunner to shoot—the squadron pilots, bombardiers, navigators, the gunnery officers, the air force commanders.

GUNNERY IN THE FINAL MONTHS OF THE WAR (1944-1945)

Combat Gunnery, Final Period

As the remaining months of 1944 passed, gunnery in combat gradually changed. Again, remembered newspaper stories will serve to set the scene. Weakened by the AAF's devastating bombing of its aircraft factories and fuel plants, and warded off by our long range fighter escort, the German Air Force lost its over-all effectiveness, though its fighters could gang up and strike tellingly against single groups of bombers. And in the Pacific, the mammoth, long-range B-29's were getting into operation.

The 20th Bomber Command, with bases in India and China, was bombing Manchuria, Formosa, and the home islands of Japan. On the gruelling, 18-hour flights from their home bases to their targets, and return, the B-29's were meeting determined opposition, particularly from scattered groups of Japanese Navy fighters. Stories of intentional head-on rammings by Kamikaze squadrons were current, and stories of the effectiveness of the new fire-control equipment on the Superfort came through. Back home,

the training of gunners was simultaneously being revised and improved.

The results of the studies of psychologists of the combat gunner in the Pacific Theater were presented at a conference held in San Francisco on 31 July and 1, 2 August, 1944. The conference at San Francisco was attended by officers representing all commands concerned with gunnery and gunnery training, from Headquarters, Army Air Forces, to each of the operational air forces in all theaters of war. Such objective evidence of interest in gunnery had never before been shown.

Gunnery Research, Final Period

In the months subsequent to the initiation of psychological research in flexible gunnery, the research program had grown rapidly. With a small group of psychologists forming a nucleus, there had gradually evolved a large departmentalized research and developmental organization, staffed by psychologists, mathematicians, physicists, engineers, draftsmen, writers, artists, and gunnery training experts, totaling some 250 people, and competent to undertake almost any problem in flexible gunnery training. The Research Division, as it was designated, is believed to have been a unique organization in the Army, marshalling, as it did, the efforts of a varied group of experts to the common purpose of solving a difficult technical problem.

The gunnery conference at San Francisco resulted in greater emphasis on research on crew-training of gunners, and on refresher training for gunners in combat. An extensive research project was set up at Pueblo Army Air Base, resulting in the publication, in October of 1944, of a standard B-17 and B-24 gunnery program for all training air forces, a program which was founded on the results of the evaluation of several training methods tried out at that station. Several months later, in January of 1945, a similar though somewhat broader research undertaking was initiated in the 8th Air Force by psychologists from the Central School. This investigation was directed toward establishing the most efficient training procedures for maintaining the basic skills of gunners during their combat tour. The study was completed to the immediate benefit of the gunners involved, but the training program determined to be most effective was not put into widespread use, due to the end of the war in Europe. At the same time that these studies were being carried out, the Central School was turning its attention to the problem of training B-29 gunners for the Pacific war. The responsibility for planning a program for the training of B-29 gunners was borne almost wholly by the Research Division.

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Gunnery Training, Final Period

A comprehensive plan for the training of B–29 gunners was worked out and put into effect at Buckingham in January 1945. To define concretely and specifically the objectives which should guide the training program, an officer was sent to the 20th Bomber Command to study combat requirements. The basic course was lengthened from 6 weeks to 12 weeks; new lesson plans, new examinations, and new phase checks were developed; a B–29 supplement to the Gunners Information File was published; ground ranges were modified; a special B–29 synthetic trainer was devised; several motion pictures and film strips were produced; and coordination with other training elements was carefully worked out. The significance of this account is that the program was conceived as a whole, and not piece by piece. It was the first integrated plan for the training of gunners, based on what gunners had to do in combat.

Other Developments, Final Period

Concurrently with the planning of a new B–29 training program, there were several notable developments in flexible gunnery. In August of 1944, the National Defense Research Committee contracted with the University of Wisconsin to establish at Laredo a project to study psychological problems in the design of gunnery equipment. This was a most significant undertaking for it was the first experimental program devoted to the systematic study of the design of equipment with reference to the abilities of the gunners who would use the equipment. The training of B–29 gunners gradually superseded the training of gunners for B–17's and B–24's. A program for the training of A–26 gunners was put into effect, and plans were in progress for the training of B–32 gunners. Radar appeared as an aid to aiming of flexible guns, opening up an entire new field for research and auguring a revolution in the concept and potentialities of gunnery. Such was the picture as the war drew to a close.

CHAPTER TWO

The Gunner's Job

Capt. JOHN A. VALENTINE

INTRODUCTION

It was the flexible gunner's primary responsibility to protect his bomber, and other bombers in his formation, from attacks by enemy fighter planes.[1] His fundamental job, therefore, consisted of aiming and shooting at attacking planes so that they were put out of action or at least deterred from making effective attacks.

In this chapter, the basic problem of shooting at attacking planes will be discussed; the complex aiming situation that was involved will be developed; and the equipment provided the gunner to solve his basic problem, as well as his duties with respect to this equipment, will be briefly described. The gunner's actual success in shooting at enemy planes will be discussed, and, finally, those aspects of his job concerned with his role as a member of an aircrew will be described.

THE FLEXIBLE GUNNERY AIMING SITUATION

The Sighting Problem Analyzed

The gunner was faced with the problem of shooting from his fast moving bomber at a target that was also moving rapidly through space. A helpful way to view this problem is to consider it as an elaboration of simpler and more familiar aiming problems. These may be conveniently analyzed in terms of the moving or stationary character of both the gunner and his target.

Stationary gunner and stationary target.—A boy with a small-caliber rifle shooting at a tin can is an example of the basic aiming situation. If he lines up his sights accurately on the can, and holds the alignment while squeezing the trigger, he may confidently expect to hit the can. The factor of equipment is present, of course, and it must be assumed that the sights are

[1] The terms "flexible" gunner and "aerial" gunner were used interchangeably in the early days of the war. Later, flexible gunner became the preferred term. It is used throughout this report except in a few quotations and titles which retain their former usage.

properly adjusted, and that both his rifle and ammunition are in effective working condition.

Stationary gunner and moving target.—If the boy takes his rifle to a shooting gallery, and tries his luck shooting at the small clay birds as they move slowly and steadily around a track, he faces an aiming problem of the next degree of difficulty. It is no longer possible for him to aim directly at the target, because in the time it takes his bullet to reach the target, the target itself has moved a certain distance. The task has become one of so directing the bullet that it will meet up with the target. In aiming, therefore, it is necessary to lead the target by the correct amount. At a shooting gallery it is usually a matter of no more than a couple of inches of lead, and the problem is not exceedingly difficult.

Moving gunner and stationary target.—If the boy in the original example were to try and hit the can with his rifle while riding by in a fast moving automobile, he would face a yet more difficult problem. This time he would not have to estimate how far the target would move in the time it took his bullet to reach it, but he would have to allow for the fact that his own forward motion is imparted to the bullet when it leaves his rifle. If riding by from left to right of the can, he would find that he must aim at some point to the left of the can in order to hit it, the point varying with the speed of the automobile and its distance from the target.

Moving gunner and moving target (flexible gunnery).—The ultimate aiming problem is encountered when both the gunner and the target are moving through space. This was the problem of the flexible gunner. The bullet would not go where the gun pointed, because it was affected by the motion of the base from which it was fired, and the target changed its position in space from the time the trigger was pulled until the bullet reached its vicinity. The gunner somehow had to take into account both of these motions.

He had at his disposal one perceptual phenomenon of considerable assistance, and that was the apparent motion of the target. If he observed how the target *seemed* to be moving through space, he had his cue for the direction of lead called for. If the target were traveling in his same direction at the same speed, it would seem to be standing still, and so he would aim directly at it. If the target were moving faster than he was, it would seem to be slowly forging ahead, and he would aim in front of it, as in the shooting gallery example. If the target were moving more

slowly than he was, it would seem to be dropping behind, and he would consequently have to aim behind it.

By carefully observing the apparent motion of a target it was possible for the gunner to determine the direction of lead (in front of or behind the target) with some certainty. The determination of amount of lead required imposed a far more difficult problem in perceptual judgment.

Other Factors in the Sighting Problem

Having developed the flexible gunnery situation as one involving both a moving gunner and a moving target, it is important that certain more specific characteristics of this situation be kept in mind in order adequately to appreciate the gunner's aiming problem.

The target size.—Fighter planes varied in size during the war, largely depending on the number of engines they possessed. The most important dimension from the gunner's point of view was the wingspan, as this was most often the target presented to him. Wingspans for single-engine fighters averaged around 35 feet; for twin-engine fighters around 60 feet. The more vulnerable portions of the target, the propeller, engine, and cockpit, were usually contained in a space approximating the size of a small truck. The impressive smallness of such a target is realized when one considers the usual distance of the target from the gunner.

The target distance.—Attacking enemy fighters would usually open fire at a distance of about 600 yards, and would break off their attacks at from 50 to 200 yards. With some types of sights, the gunner was encouraged to open fire on a fighter at a range of as much as one thousand yards, in which case it looked like a large speck on the horizon. In most cases, however, he was advised to wait until the enemy was six hundred yards or less from his plane, at which stage the target was beginning to look roughly like a dime held edgewise at arm's length.

The target path.—When flying in fairly close formation, a gunner would sometimes have occasion to fire at enemy fighter planes attacking other bombers than his own. In most instances, however, he would be called on to shoot at planes attacking his own plane. For an enemy fighter plane attacking a bomber, there were two basic types of attacks. Both types of attacks were influenced by the fact that the guns on a fighter plane were characteristically fixed in a set position on the plane, so that pilots had to aim their planes in order to aim their guns. The first type of attack was one in which the fighter pilot attempted to place a burst of rounds in the path of the bomber, while con-

tinuing to fly a fairly independent course. Fighter planes making such attacks (commonly referred to as "fly through" attacks) rarely presented satisfactory targets, but in turn rarely made effective attacks.

The most common target paths were those that permitted the fighter pilot to keep his guns aimed so as to effect hits on the bomber. Direct head-on and tail attacks permitted this. Frequently, however, the fighter pilot would overtake the bomber on one side or the other, and then move in on the bomber while holding his plane aimed at the proper distance in front of the bomber's nose. This forced a definite relationship between the position of the bomber and that of the attacking fighter, and caused the fighter to fly what was known as a "pursuit curve."

A pursuit curve may be visualized by imagining a dog running to meet a hunter, who is walking across his path of movement some distance away. It is necessary for the dog to keep changing his direction until he catches up to the hunter from behind. In the same way, an attacking plane might turn in upon a bomber while directly alongside it. While flying so as to keep pointed somewhat in front of the bomber, its position would gradually change in towards the bomber and behind it. To a gunner on the bomber it would always appear that the attacking plane was floating rapidly into and towards the rear of his own plane. This apparent motion indicated that the guns should always be pointed between the attacking plane and the tail of the bomber.

Length of attack.—To complete the flexible gunnery aiming situation, it is important to include the fact that a fighter attack usually lasted from 3 to 6 seconds. In that brief span of time the gunner had to coordinate all of his aiming and firing activities.

FLEXIBLE GUNNERY EQUIPMENT

Throughout the war gunners were supplied with a variety of types of equipment to assist them in aiming and shooting at attacking planes. As the war progressed, gunnery equipment tended to become more and more complex and specialized. In general, it gradually took over the solution of much of the gunner's aiming problem, although leaving him with difficult tasks of perceptual judgment and motor coordination. The following paragraphs contain brief descriptions of some of the more common items and types of gunnery equipment. Much of the gunner's time was spent in caring for his equipment and making it ready for combat use.

The Caliber .50 Machine Gun.

The caliber .50 machine gun as used during the war weighed some 60 pounds and contained over 150 working parts. It fired a round one-half inch in diameter, weighing almost 2 ounces, that was either armor piercing, high explosive, or incendiary. It fired approximately 800 rounds a minute. Its maximum effective range was about 1,000 yards.

Two characteristics of the gun are of importance in understanding its role in the gunner's job.

Bullet dispersion.—The gun did not remain stable as a burst of rounds was fired. Even when the gun was mounted in cement, the barrel would "whip" enough to cause the rounds to emerge in a variety of divergent paths. When the gun was fired from a typical gun mount, this whipping effect was more pronounced. For certain typical mountings of the gun, the dispersion of rounds amounted to an area with a diameter of approximately 12 feet at a range of 1,000 feet.

Barrel heating.—It was not possible to fire the caliber .50 machine gun for more than a few seconds at a time without overheating and damaging the barrel. This meant that the gunner would have to space his bursts, thereby decreasing his overall fire power.

Much of the gunner's time was spent in adequately maintaining his machine guns. He was typically expected to clean and oil them after each mission and to make proper adjustments and check their condition before each mission. He was also expected to know how to adjust the sight so as to be in line with the bore of the gun, a process called "harmonization."

Turrets

Locally controlled turrets.—To facilitate the use of the machine guns, units known as local gun turrets were eventually installed in many of the bombers. Each turret included space for at least two machine guns, a sight, the gunner, and his personal equipment. Turrets were driven by electric, hydraulic, or combined electric-hydraulic systems. Local turrets, moving in azimuth and elevation independently of the movement of the bomber, provided the gunner with a maximum amount of area in which to search for, aim, and shoot at enemy planes. The gunner operated his turret with hand controls and a variety of switches.

It was usually the gunner's responsibility to load ammunition into his turret and to make careful preflight and postflight checks of the turret's condition and operation. Some gunners were also required to harmonize the guns and sight in their turrets and to make periodic checks of the harmonization.

Remotely controlled turrets.—In some of the bombers produced toward the end of the war, a system of remotely controlled gun turrets was adopted. The gunner would sit at a sighting station, from which he was able to scan an area of the sky and to control the action of one or more gun turrets located some distance from his position. This type of gunnery situation had the advantage of minimizing the effect of gun vibration on the gunner's aiming activities, and generally made the gunner's lot a more comfortable one.

The gunner's task with respect to this type of equipment usually consisted of loading ammuntion into the turrets and making routine preflight and postflight checks of the system's operation.

Sights

The most significant contributions to the gunner's aiming problem were made by the sights that were developed for his use. Commencing with simple devices that gave the gunner a minimum of assistance in arriving at an aiming solution, they eventually were designed to predict with some certainty the amount and direction of lead required for various attacks. The judgmental aspect of the gunner's aiming task was consequently gradually superseded by complex but more purely perceptual and motor aspects.

Following are descriptions of typical sights.

Iron ring-and-post sights.—The simplest type of sight employed in flexible gunnery was an elaboration of the sights found on any small rifle. These sights consisted of an iron ring, usually containing one or more concentric rings, mounted toward the rear of the gun, through which the gunner lined up the target with reference to the beaded top of an iron post set near the muzzle end of the barrel. Each ring was usually designed to represent so many mils[2] of angular distance, and by reference to the rings the gunner was able to estimate the range, measure off leads or deflection, and track the target.

On the basis of mathematical computations, it was possible to determine, for certain typical bomber speeds and altitudes, the approximate lead required in order to hit an attacking plane during various stages of its pursuit curve flight. Simple rules making use of these calculations were evolved for gunners employing ring-and-post sights. The lead was customarily expressed in terms of the radius dimension of the innermost ring. Thus, the lead required when a fighter was directly abeam of the bomber

[2] The mil, a unit of angular measurement used in flexible gunnery, is equal to approximately 1/6400 of a circle. More precisely, one mil is the size of a central angle subtending a chord of 1 foot at 1,000 feet.

and in an attacking position was expressed as three sight radii, or "rads"; when the fighter was 45° from the bomber (and toward the bomber's tail), the lead was two rads. The lead would decrease until the fighter was behind the bomber and no lead at all was necessary. The perceptual problem of estimating and setting off the appropriate rad leads was impressively difficult.

Optical ring sight.—The optical ring sight was a device providing the gunner with the same reference features described for the iron ring-and-post sight, but in a more convenient manner. The gunner ranged, aimed, and tracked by reference to rings projected on a transparent viewing glass. The rings seemed to the gunner to be projected into space, which most gunners reported as facilitating aiming activities.

Compensating sights.—In order to relieve the gunner from the necessity of setting off the appropriate leads during a pursuit curve attack, a type of sight known as a compensating sight was developed. This sight permitted the gunner to aim directly at the target at all times and mechanically fixed the guns in position for the proper lead. Early models of this type of sight were relatively simple in construction and were so adjusted as to set off leads for only one set of typical bomber-speed, altitude, and ballistic conditions. Into the more complex sights that were developed later it was possible for the gunner to set the crucial factors of his own speed and altitude, and thereby regulate the amount of lead allowed for. Compensating types of sights were useful against pursuit curve attacks, and were of course suitable, as were all sights, for direct head-on and tail attacks. For attacks requiring some deflection other than pursuit curve attacks, such as attacks being made on other bombers in the formation, they were of less value.

Computing sights.—Some sights were developed, during the war, which would determine the correct lead for any type of attack, taking into account in each particular case the factors of altitude, bomber speed, target range, and the rate and direction of the target's apparent motion. Such sights were called computing sights. Eventually employing the gyroscope, as a means of accurately translating rate and direction of movement into the appropriate gun deflections, these sights required for their effective operation the setting in of accurate altitude, bomber speed, and target wingspan data, and the smooth tracking and framing of the target for a definite interval of time. With such a sight, the gunner's job consisted of first making the proper settings, and then aiming directly at the target and smoothly following its course (to supply direction and rate of motion data to the sight).

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while at the same time continuously adjusting movable lines or sets of points on the sight finder so that they would exactly frame the target as its apparent size changed. This operation supplied range information to the sight. Computing sights in general provided the gunner with the greatest amount of assistance in his solution of the aiming problem.

Radar sighting aids.—Radar devices were eventually used with certain computing sight systems to supply information to the sight regarding the range of attacking planes, thereby considerably simplifying the gunner's task by eliminating the difficult framing operation.

FLEXIBLE GUNNERY EFFECTIVENESS

Having pointed out the difficulties of the flexible gunnery aiming situation, and briefly having described the equipment supplied the gunner to assist him in overcoming these difficulties, it is pertinent to devote some attention to the actual effectiveness of gunners in using their equipment to destroy or damage attacking enemy fighters.

Some of the best gunnery records were made by the B-29 gunners operating in the 20th and 21st Bomber Commands in the Asiatic-Pacific Theater. These gunners had the most advanced gunnery equipment available during the war, and had the advantage of flying in bombers that went faster than all other heavy bomber types, thereby somewhat limiting the possibilities for enemy fighter attacks. The following report was submitted by one bombardment wing, summarizing the results of 36 missions over the Japanese mainland prior to 7 April 1945: [3]

Number of enemy fighter attacks reported	5978.
Number of enemy aircraft destroyed	252.
Number of enemy aircraft probably destroyed	171.
Number of enemy aircraft damaged	307.

These data reveal that 7.08 percent of all enemy aircraft attacks encountered during the period in question resulted in destruction or probable destruction of the enemy planes, and that 13.9 percent resulted in destruction, probable destruction, or damage of the enemy planes.

It is interesting to note the number of rounds expended to shoot down or damage attacking fighter planes. During a B-29 mission cited as being very successful in the report referred to above, 205,137 rounds were fired, accounting for 79 enemy aircraft destroyed, 23 probably destroyed, and 50 damaged. Some of these rounds were expended in test firing of the guns, but in

[3] Consolidated Mission Report, Field Order No. 73, Headquarters, 73d Bombardment Wing, 7 April 1945.

general the figures reported provide a picture of what was generally considered to be combat gunnery at its best.

The difficulty of the flexible gunner's task was not a function solely of combat conditions. All attempts to set up a training situation which would simulate the gunner's combat task were hindered by the fact that gunners would not score enough hits to enable them to discover what their correct performance should be.[4] For example, a most realistic simulation of combat gunnery making use of an armor-plated fighter plane at which the gunner fired special projectiles that disintegrated harmlessly upon contact, proved relatively ineffective as a training and scoring device because the average gunner would hit the attacking plane (thereby activating an electrical scoring system) with only 3 percent of his rounds.[5]

THE GUNNER AS A CREW MEMBER

Although the aiming and shooting activities of the gunner have been stressed most in this chapter, bearing as they do most directly on the accomplishment of his ultimate objective, it must not be supposed that his duties began and ended with these activities. Some gunners often had other aircrew responsibilities, such as navigating, bombardiering, and airplane maintenance. B-29 gunners served as "eyes" for the pilot and flight engineer, informing them of control-surface, landing gear, and engine conditions. Even the man whose only job was gunnery, however, was a member of a cooperative fighting team, and as such had to be familiar with a variety of procedures and equipment.

Briefly, a gunner had to be proficient in the use of interphone equipment, oxygen apparatus, and articles of electrically-heated clothing. He had to know how to administer basic first aid. He had to be ready to parachute from his plane on short notice, or to play his particular role in the event of a forced landing on water. He was expected to be alertly observant at all times so as to be able to give accurate and pertinent information on conditions observed during a mission.

SUMMARY

The flexible gunner's basic job of shooting at a rapidly moving fighter plane from his own rapidly moving bomber was a difficult one, resulting even under optimum conditions in a very small percentage of hits. For the accomplishment of his job, the gun-

[4] See chapter 5 for a further discussion of this fact as it was related to the establishment of a criterion of gunnery success.
[5] See chapter 9 for a more complete description of this type of training.

ner was supplied with caliber .50 machine guns, usually mounted in power-driven turrets. Various types of sights were supplied to help the gunner solve his aiming problem. Much of his time was spent in caring for this equipment, and making it ready for combat use. He also had to be able to play his role as a bomber crew member, fighting under unusual conditions of temperature and atmosphere.

CHAPTER THREE

The Gunner

Lt. GERALD R. PASCAL

In the application of psychological techniques it is important to know the characteristics of the individual to whom the techniques are to be applied. For instance, in planning a training program it is necessary to know the intellectual level and educational background of the prospective students so that courses of study may be adjusted to their abilities. It is necessary to know something of their age and adjustment, so that problems of selection and training can be placed in proper perspective. By way of introduction, this chapter will survey briefly materials pertinent to an understanding of the man who was the focus of the psychological approach to the problems of flexible gunnery.

THE GUNNERY STUDENT

The Men Who Were Gunners

Below are several brief case histories of men who were gunners. These particular case histories were selected and condensed from several hundred detailed case histories of men back from combat. If one keeps in mind that there were notable deviations from the mode suggested by these thumb-nail sketches, they will serve well to introduce the men who are the concern of this report.

Staff Sergeant Williams was born in a small midwestern town. He was 24 years old. His school and homelife were happy and satisfying. He graduated from high school and expected to enter an engineering college. However, his father died and he was forced to help support the family, giving up his plans to attend college. Until he entered the Army in 1941, he worked primarily at wholesale saleswork for a nationally known cheese manufacturer. During the period between leaving and entering the Army he reported that he was active socially and that hunting, fishing, and ice skating were his major hobbies. Sergeant Williams was severely wounded on his fourth mission.

Sergeant Augburg was 22 years old. He was born in Austria and came to the United States with his parents in 1924. He was an only child. His parents lived in a small town in Connecticut. His father was a metal polisher. Sergeant Augburg completed two and one-half years of high school. He quit high school to attend a trade school for an additional two and one-half years where he learned printing. Before entering the Army he worked for five months as a linotype operator earning $1.48 an hour. He was a

member of the swimming team of his factory. In December of 1942 he enlisted in the Air Corps. He was flying as armament gunner on a B-24 and was on his 74th mission over the Philippines when the wing was shot off his plane. He bailed out and was taken prisoner.

Sergeant Antoni was born and reared in the Bronx, New York City. He was 23 years old. His parents were born in Italy. His father was owner of a grocery store in the Bronx. The sergeant was next to the youngest in a family of five children. He graduated from high school and then took one year of post-graduate work learning typing, stenography, and business machine operation. He had planned to go to college but, instead, obtained a job at a race track and learned to be a jockey. Sergeant Antoni successfully completed his missions as a radio operator-gunner in the European Theater of Operations.

Perusal of case history files on gunners bears out the rich variety of American family backgrounds. Gunners varied in education from incomplete grammar school training to post-graduate college training. Intelligence ranged from below average to very superior. Case histories serve to direct attention to the individual, but in order to get a more comprehensive picture, some statistical data are required.

Estimates of Gunner's Intellectual Level, Education, and Age

The training program could not be addressed to each individual but, for the sake of economy, had to be directed towards the great majority of individuals presented for training. In considering intellectual level, then, it was important to know the average Army General Classification Test score of basic gunners, their Mechanical Aptitude Test scores, and other facts which served to characterize the majority of gunnery students.

General intelligence.—There was great variation in the Army General Classification Test scores of men in basic gunnery schools. Although the lower limit for gunners was set at 85, actually, men with even lower scores sometimes arrived at gunnery schools; but these were few in number. The found range of Army General Classification Test scores was from 64 to 154, for a population of 2,629 basic gunners. The mean score for this group was 110.3 with a standard deviation of 14.3. This mean score is several points higher than the mean score of enlisted personnel in the Army as a whole. The distribution of scores is illustrated in figure 13.1.

Mechanical aptitude.—Mechanical Aptitude Test scores varied as did the Army General Classification Test scores, and the range was as great. For the population of 2,629 gunners studied, the mean Mechanical Aptitude Test score was found to be 106.4, with a standard deviation of 14.3. Thus, in spite of the wide variation, about two-thirds of gunners had an Army General Classification Test score of between 96 and 125, and a Mechanical Aptitude Test score between 92 and 121. These scores were noticeably better than scores for the Army population as a whole.

Education.—There was also a wide variation in the educational background of gunners (see table 3.1). For 2,659 gunners in the

TABLE 3.1.—*Educational level of gunners: percent of ex-combat gunners indicating various levels of educational attainment (N=2,659, training air force stations, latter half, '44)*

Educational level	*Percent attaining level*
Less than 8th grade	1.7
Completed 8th grade	8.1
One to two years, high school	18.0
Three to four years, high school	60.3
One year, college	5.7
Two years, college	3.6
Three years, college	1.2
Four years college	1.1
Some post graduate work	.1

training air forces, education ranged from below eighth grade training (1.7 percent) to graduates of colleges (1.2 percent). Sixty percent reported 3 or 4 years in high school or vocational school. Relatively few gunners had an education beyond high school, only 12 percent of the group under consideration. The average gunner's education consisted of about 3 years of high school, but the gunner one was most likely to meet was a high school graduate.[1]

Age.—The age of flexible gunnery students was limited by the nature of the job to be done and the stringent physical qualifications for aircrew training. For two classes at Tyndall (42–40 and 42–43) and one class at Fort Myers (44–4), with a total of 646 students, age was found to range from 18 to 37, inclusive, with the mean age of 23.5. Relatively few gunnery students were over 30 years of age, 8 percent of the groups under consideration. Seventy-three percent fell between the ages of 19 and 25.

The average high school student has completed the 11th grade, which was the average school grade of gunnery students, at the age of 17. The mean age of basic gunnery students was about 23.5. Then it follows that, on the average, the basic gunnery student had been out of school for 6½ years, which was an important consideration in planning a training program.

The Gunner in Training and in Combat

The men who have been described above were sent through an intensive training period and then into combat. A brief description of the sequence and nature of gunnery training, and a sketch of what combat gunnery was like, will serve to provide necessary background for understanding research materials to be reported later.

[1] This study was conducted by a detachment of psychologists from the AAF Training Command. Personnel of this detachment were subsequently assigned to the Office of the Surgeon, Headquarters, 3rd Air Force.

Basic training.—The potential gunner arrived at basic gunnery school after having attended, for several months, one of the Air Forces technical schools, and was rated an airplane mechanic, radio operator mechanic, or armorer. (Some men, called "career gunners," came directly to basic gunnery school). He may have been drafted into the army and sent directly to gunnery training. He may have volunteered for gunnery from ground duty or another branch of the service. Or he may have been disqualified for or eliminated from aviation cadet training and assigned to enlisted aircrew training. Usually, upon arriving at the reception pool for flexible gunners he was rated a private-first-class (if he had been to a technical school, private if he had not), with the expectancy of becoming a corporal upon completion of basic gunnery training.

In gunnery school he began his training for aerial combat. He learned about the caliber .50 machine gun. He shot at skeet birds from the ground, from trucks, from turrets. He went to lectures and to various ranges. He learned aircraft recognition. He learned about a turret. He practiced on various synthetic trainers. Finally, he arrived at the air phase of his training. He went up to shoot in the air. He shot at targets towed by another plane. He learned to strafe. He shot camera film at attacking fighter planes. He went on missions at high altitudes, learning to use his oxygen equipment. Meanwhile, he had taken many tests, passed several phase checks. He had assembled his caliber .50 machine gun blind-folded. He had demonstrated he could detect malfunctions in it. He had shown he knew his turret. He had made a qualifying score shooting the caliber .50 gun at a moving target. He had arrived at the final comprehensive examination. He had passed it. One day, after 6 weeks of the hardest, most concentrated training he had ever had in his life, he got his wings. He was a gunner.

Combat crew training.—After basic gunnery training the average gunner was sent to one of the training air forces for combat crew training. Here, for the first time he met the other members of his crew. Here, for the first time he began to get the feeling that he belonged. He was subjected to further months of training, in flying and shooting with the other members of his crew. Perhaps he was assigned to a gun position other than that for which he was trained, or, perhaps, to a different type of ship. He had to learn this new position, and possibly a secondary gun position. Here, he learned to be a fully responsible crew member. If he was an airplane mechanic he had also to be that, besides being a gunner—or a radio operator, or the airplane's armorer. He

learned to take care of his equipment on a combat-equipped airplane.

Combat.—Overseas, the gunner often had many more weeks of training before his first combat mission. There were weeks of practice, weeks when he had to learn about the conditions of his combat theater, weeks when he had to become proficient in the exercise of his skill. He learned to prepare for missions with care. He learned tactics, those of his own bombers and those of enemy fighters.

Then one day he was briefed for his first combat mission. He had prepared his equipment. He had, mentally, accepted the hazards of combat.

He left the comparative security and comfort of his base. Usually he had hours of waiting, constantly on the alert, hours of boredom, even, to overcome, tedious hours while his airplane droned on to a distant target. If the mission was at high altitude, he had, in addition, to endure the physical discomforts of sub-zero weather and the constant threat of oxygen deprivation. After hours of inactivity, he had to exercise split-second judgment and precise psychomotor control to meet enemy fighter attacks. He had to withstand the frustration of seeing flak burst in and around his airplane, watch helplessly while bombers of his formation went down. He had to learn to react rapidly and precisely after hours of waiting, if he was to perform his combat job satisfactorily.

The Motivation of Gunners

The materials above indicate in broad outline something of the abilities and the background of gunners and something of the experience of gunners in training and in combat. There remains one factor, important for the understanding of the research to be reported, and that is the motivation of gunners.[2]

The gunners' concept of their job.—Students in the basic course at Buckingham were asked to write their opinions about gunnery. These comments were anonymous and illustrated well the nature and range of gunners' concept of their job.

> Today was my first day of attendance as a gunnery student at this school. On the basis of what I've seen this first day, I feel this training is going to be the best. The classes are semi-informal. The instructors are regular fellows, and, not for one moment can the student feel that the instructor isn't well-versed in his subject. Flattersome as hell, isn't it? Yet, those are really my first hand impressions of the school. But, I have one irksome gripe, and I'm not alone in feeling the injustice of it. Been a corporal for nigh onto 2 years. Went through 6 months of training as an air cadet, was eliminated at basic flying school in February 1943. Returned to previous rating of a corporal, was reclassified, and sent to Scott Field for ROM. Graduated from that and finally after numberless delays all along the line, find myself a student at gunnery school, and a corporal (still).

[2] The attitudes and adjustment of gunners will be discussed in detail in Chapter 10.

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Frankly speaking, I never did give a damn for radio, code, etc., and now gunnery, which I despise. Was an aircraft mechanic for years, desirous of being an AM and here I am in this damned outfit. Of course the army is

I want to fly more than anything else in the world. I was disqualified as a cadet which disappointed me greatly. When I learned that I would have to go to gunnery I was glad to be part of the best combat crew in the world. My one objection is the rating. I think every man who is good enough to be on a flying crew is good enough to be a flight officer. A whole crew's life depends on each individual.

I think you would have better students, a better school and better gunners if it were made a voluntary move. I am not the least mechanically inclined and have no desire to fly. Personally, I am convinced I am better suited and would be much more credit to the army in one of the two or three lines I am better suited for.

When I entered the Army they told me I was physically fit to be a flexible gunner. Since then, two of my best friends have been killed in the Royal Canadian Air Force. I want to get a chance to kind of pay off the lousy —— that caused all this trouble.

I *do* want to be a gunner. There's nothing I'd rather be, and that includes pilot. To me, a gunner is the backbone of a mission, the *protector* of the pilot and the crew. Without him, the mission would fail miserably.

Motivation varied.—There was much variability in motivation, as is nearly always true in such circumstances. Some men were proud to be gunners and worked hard at being good gunners; more men were willing to make the best of a situation not too much to their liking; others were apathetic, indifferent; a few were hostile and actively sought to get out of gunnery. Further, attitudes and motivation varied with time and with place of assignment. In the earliest days when all gunners were volunteers, it is said by gunnery experts that motivation was intense, only to fall off when men were ordered into gunnery training without regard to their wishes. Motivation took a downward drop when the ratings given to gunners upon graduation from basic school were gradually lowered from staff sergeant, to sergeant, to corporal, and to private-first-class. Attitudes became more favorable in the Training Command schools as the course of training was improved; attitudes were generally more unfavorable in the training air forces where the gunner was neglected in favor of the pilot, bombardier, navigator. Attitudes improved when, in early 1945, some Air Force men were being transferred to the Ground Forces. In a few overseas groups, particularly in B-29 outfits, gunners were reported as alert and "on the ball"; in most groups, the gunners were held to be lacking in a desire to do their jobs well.

Motivation was low.—Though there was much variability, the mean motivation of gunners was much lower than observers felt it might have been, much lower than it should have been to make gunnery maximally effective. The difference between the attitudes of gunners in training and of aviation cadets was striking. Cadets were highly selected, highly motivated, and they were working toward a job that carried great prestige, and many rewards. Gunners were generally cast-offs, motivated only as much

as most people are motivated when they are given a fairly important job to do, and they were working for a job that carried less prestige and fewer rewards. That these differences extended through combat is evident in the fact that only 52 percent of gunners were favorable in some degree towards return to combat, whereas 80 percent of the commissioned aircrewmen expressed some willingness for a second tour.

Two major causes of low motivation.—Though one may be sure that there were many complex factors operating in the motivation of gunners, there are two factors which may be identified as generally contributing to low motivation.

First, the status of gunnery in the Air Forces was uncertain. Although the number of men required for flexible gunnery was a sizeable percentage of the men trained by the Air Forces, emphasis on the training of flexible gunners came relatively late. Flexible gunnery was at first relegated to a minor role, as compared with other types of training, but, later, with increasing awareness of its importance, it was given high priority. Then the gunnery program swung into action with an intensity which left little time for mature consideration of such intangible problems as motivation. The gunner was sometimes considered important, sometimes not; his significance to the success of combat sometimes crucial, sometimes inconsiderable. His job varied with equipment and the theater of operation.

Second, there were inherent in the gunner's job conditions which militated against the development of motivation and confidence. The gunner was handicapped by a lack of a reliable criterion against which he could measure his proficiency. Gunners seldom knew whether they were good, poor, or indifferent with respect to their jobs. This fact worked contrary to all that is known about the importance of knowledge of achievement in a situation where strong motivation to master a difficult task is required.

From these two general conditions, there evolved many of the specific circumstances which reduced motivation and contributed to low morale among gunners.

SUMMARY AND CONCLUSIONS

This chapter began with a quick look at background material from which to consider various facets of the gunner's make-up. Data presented have indicated that the gunner was an average young American, about 23 years old with, typically, a high school education, and was somewhat above average in intellectual endowment. He came from all parts of the country and from all walks of life. What had been considered a highly specialized task, only open to selected volunteers, was accomplished by draftees, average

American youth. The presence of a large group of gunners who were relatively unmotivated to do their best in training for their job is pointed out. How much more efficient the gunner might have been, how many more lives might have been saved had he been well motivated throughout training and combat, these questions form the core of the problem of motivation, a problem realized, but a problem which, due to the exigencies of the situation, had to remain relatively untouched.

CHAPTER FOUR

The Role of Psychologists in Flexible Gunnery Research

Maj. NICHOLAS HOBBS

INTRODUCTION

Research in flexible gunnery was started by psychologists. They were few in number, at first, and their research mission was confined to the problem of improving techniques for the selection of basic gunners. Gradually demands on research increased, for the job of the flexible gunner presented many new problems for which there was no accumulation of experience-wrought solutions. The mission of psychological research was broadened to include problems of training, and additional psychologists were assigned to duty in gunnery. Other scientifically trained personnel, mostly physicists and mathematicians, were added to the staff of the Central School to work on problems of gunnery theory and technique. Engineers were called in to work on equipment and on training devices. Later, writers, artists, and publications men were assigned to the Central School. It was their job to make gunnery simple and easy to understand through textbooks, pamphlets, and posters, through films and film strips. Finally, there was in research a group of men whose special qualification was that they knew gunnery thoroughly.

This report is not a full chronicle of the achievements of all of these men. The nature of the series of reports, of which this report is one, demands that the account be limited to work of a psychological nature. Although the work to be reported in the following chapters is concerned only with the psychological aspects of research in gunnery it is evident that many people, not all of whom were psychologists, contributed to the work.

As a background for this report it will be helpful to know something about the organizations which provided a framework for research in gunnery and to know something about the defined missions of these organizations.

Early Research Organizations in Flexible Gunnery

The three original research detachments.—In September of 1942, three small detachments of psychologists were sent to Las Vegas, Harlingen, and Tyndall for the purpose of administering a battery of aptitude tests on the basis of which a few gunners from each graduating class would be recommended for training as low-altitude bombardiers. In addition to outlining procedures for testing prospective bombardiers, the directives issued to these detachments provided for exploratory work on the problem of developing an aptitude test for the selection of men to be trained as gunners. Thus the first research project in gunnery was quite narrowly defined. The work of these three groups was terminated in December 1942. However, interest in psychological research had been stimulated, and gunnery officials requested that the work be continued.

Psychological Research Detachment (Gunnery).—To carry on the work which had been initiated, personnel were drawn from each of the three original detachments and assigned to the Psychological Research Detachment (Gunnery) which was activated on 1 March 1943. This detachment was stationed at Buckingham and worked in closest affiliation with the Instructors School. Its mission, somewhat more broadly defined than the mission of the original detachments, was stated as follows:

> The detachment shall continue the work already started on improving the procedures for the selection of flexible gunners. It will administer a recently constructed aptitude test for flexible gunners for the purpose of establishing norms and obtaining other needed research data. The detachment will, from time to time, check on the validity of the proposed test and carry on research directed toward increasing its efficiency in the selection of gunners.
>
> Since intelligent selection of gunnery students is intimately connected with determining accurately the relative success in school of students selected, the detachment will do research directed toward achieving uniform and reliable measures of success in academic work, ground range firing, and air-to-air firing at all the gunnery schools.[1]

Psychological Research Unit Number 11.—The gunnery research detachment worked for a period of approximately 6 months, laying the groundwork for much of the research that is the substance of this report. During this time, psychological research gradually became established as an essential activity in the gunnery training program. The temporary detachments evolved into a permanent unit, which was designated Psychological Research Unit No. 11. This transition is best pictured in the following quotation from a letter from the Commanding General

[1] Letter, Headquarters, AAF Flying Training Command, dated 17 February 1943, Subject: Establishment of Psychological Research Detachment at Central Gunnery Instructors School.

of the Army Air Forces Training Command, which defined the mission of the new unit:

There has been in existence, since 1 March 1943, at Buckingham Army Air Field, Fort Myers, Florida, a Psychological Research Detachment (Gunnery), composed of psychologically trained officers and enlisted men on detached service from the Psychological Research Units of the three Flying Training Commands. The research program conducted by this Detachment has been eminently successful in that important steps toward improving the effectiveness of flexible gunnery training have resulted from its efforts. With the recent expansion of the gunnery training program there is warranted further emphasis upon work of the type conducted by the Detachment. To this end Psychological Research Unit No. 11 (Gunnery) was activated, it being the intention that the personnel of the Detachment form the nucleus of the new Unit and that the Director of the Detachment be designated Director of Psychological Research Unit No. 11 (Gunnery).

The mission of the Unit may be broadly defined as follows: To conduct research on psychological aspects of problems having to do with improving the effectiveness of flexible gunnery training methods and increasing efficiency of performance of the gunner.

Specifically, it is desired that the Unit:

a. Work towards the establishment of adequate criteria of proficiency of gunners.

b. Construct and administer tests of achievement and performance for purposes of evaluating the efficiency of various gunnery training procedures, conduct experiments upon the effectiveness of various gunnery training procedures and devices, and propose improved methods of training in conformity with psychological principles of efficient learning.

c. Develop methods of selecting instructors for the flexible gunnery training program and of selecting students for the Central Flexible Gunnery Instructors School.

d. Continue work on the construction and validation of an aptitude test for flexible gunners.

It is intended that the Unit serve as a research organization for all the flexible gunnery schools. Officials of the gunnery training program should be given full opportunity to call upon the Unit to perform special research, as the need arises, and they should cooperate in facilitating accomplishment of the mission of the Unit as outlined above. However, the Unit should confine its activities to research and developmental work and should not undertake operational activities.[3]

It should be noted that the provisions of this directive considerably enlarged the scope of psychological research in gunnery. This statement of the mission of Unit No. 11 provides an adequate definition of the objectives of the work of psychologists in gunnery throughout the war.

The period of coordinated research.—The work of Psychological Research Unit No. 11 was supplemented by the work of two other sections which were a part of the Instructors School. The first of these, designated the Proof Section was staffed by gunnery experts who were concerned primarily with improving equipment and devices used in gunnery training. The second of the two sections was designated the Analysis and Planning Section. It was staffed by civilian mathematicians and physicists, who were concerned for the most part with the theoretical solution of sighting problems. Although Psychological Research Unit No. 11 was not

[3] Letter, Headquarters, AAF Training Command, dated 23 October 1943, Subject: Mission of Psychological Research Unit No. 11 (Gunnery).

directly under the Commanding Officer of the Instructors School, local administrative arrangements were made for the director of the Unit to serve as Coordinator of Research. This arrangement assured the integration of research activities in gunnery. These two sections and the Psychological Unit developed into the Research Division.

The Research Division

With the establishment of the Central School for Flexible Gunnery in May 1944, increased emphasis was placed upon research in gunnery. The personnel of Psychological Research Unit No. 11 were assigned to the Central School, and all research activities were consolidated into one department which was designated the the Research Division. Since much of research to be reported in subsequent chapters was done by psychologists working within this organizational framework, the organization of the Research Division will be described in some detail. The organizational chart indicates by asterisks sections to which psychologists were assigned. (See figure 4.1.)

The Research Division was organized into eleven sections, the composition and functions of which are indicated below.

The Research Planning Board.—The Research Planning Board was composed of a few officers and enlisted men, competent in gunnery theory and in research techniques, who served in an advisory capacity to the supervisor of research, assisting in the planning of research projects and in the review of the results of research.

The Headquarters Section.—The personnel of the Headquarters Section discharged routine administrative duties of the organization.

The Analysis Section.—The Analysis Section was composed of civilian mathematicians and physicists. These men worked primarily on problems of gunnery theory, such as the development of sighting techniques and the determination of the theoretical adequacy of various types of sights.

The Proof Section.—The Proof Section was staffed by gunnery experts, engineers, and psychologists, who worked primarily on training devices and procedures. Suggested training devices, such as the gun camera, were examined and tested by personnel of the Proof Section from the standpoint of their mechanical and theoretical adequacy as training devices.

Curriculum Development Section.—The curriculum development section was composed of gunnery experts and a few psychologists. This section was concerned with the preparation of cur-

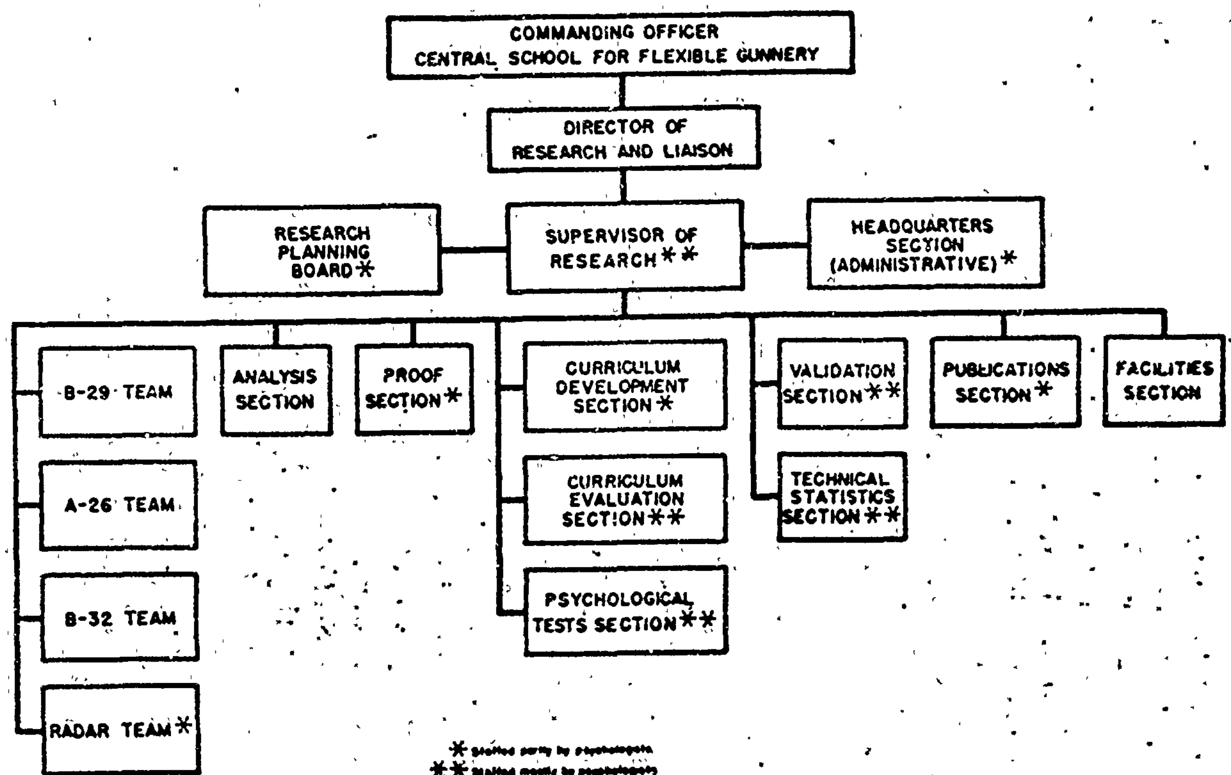

Fig. 4.1 – Organization chart of the Research Division, Central School for Flexible Gunnery, showing sections staffed by psychologists (1st quarter, '46)

riculums, lesson plans, training standards, and the materials for the Gunner's Information File.

The Curriculum Evaluation Section.—This section was composed almost entirely of psychologists. Its purpose was to provide for the systematic and continuous evaluation of gunnery training programs.

Psychological Tests Section.—The Psychological Tests Section was staffed primarily by psychologists. This section was responsible for the development of selection tests for basic gunners, for gunnery instructors, and for gunnery officers. It developed achievement tests for all basic gunnery schools and for the Instructors Course. It was also responsible for the development of the phase checks which were used in all gunnery installations in the Army Air Forces.

Validation Section.—The validation section was staffed by psychologists, who were concerned with the psychological evaluation of gunnery training devices and procedures. Studies of the reliability and the validity of scores achieved by gunnery students through a particular type of practice were normally conducted by this section.

Technical Statistics Section.—The technical statistics section was staffed by psychologists and statisticians. They were concerned with the analysis of data provided by other sections in the Research Division.

Publications Section.—The publications section was composed of professional writers, artists, and production men. This group was responsible for the publication of all training materials developed by the Research Division, including the Gunner's Information File, the phase checks, various examinations, and sundry pamphlets and posters.

The Facilities Section.—The facilities section was responsible for the administration of funds, supply, material, and equipment.

The Teams.—As is evident from the above, the personnel of the Research Division were grouped according to their special qualifications and according to types of activities. Thus one section was responsible for examinations, another for lesson plans, another for evaluation of trainers, another for publication of training aids. To coordinate the work of the various sections for training programs large in scope, several individuals were formed into "teams" and charged with the overall planning of a particular course of training. Teams to plan training for B–29, A–26, B–32, and radar gunners were established.

Cooperating Research and Developmental Groups

Although the Research Division was the focal point for research

in gunnery, there were other groups which were concerned with gunnery problems. Some of these problems involved research of a psychological nature, such as the development of rules for the use of sights where the perceptual ability of gunners was of critical concern. Other problems were of psychological interest though no research was immediately involved, such as the production of a motion picture on techniques for administering gunnery performance tests. In table 4.1 are indicated some of the more important groups, outside of the Aviation Psychology Program, which were interested in gunnery problems having some psychological significance. Personnel of the Research Division cooperated with these research and developmental groups in the types of activities indicated.

The Role of Psychologists

In a comprehensive research program, the goal of which is to improve the functioning ability of people on a job, psychologists may productively serve to tie together the work of various technical groups and give their efforts fruitful orientation. Such was the case in gunnery research. This role of psychologists in gunnery may have been a fortuitous outcome of the fact that psychologists were on the job first and that they outnumbered other specialists for a period of time. Such a possibility must be recognized. However, it is believed that there is much validity in the opinion that, where the efforts of various technical groups are concerned with problems of increasing the operational efficiency of people and of the tools with which they work, psychologists can make a unique contribution in clarifying the issues of the problem being studied and in focussing efforts of the group on critical aspects of the research undertaking.

SUMMARY

Research in gunnery was started by psychologists assigned to small detachments whose research mission was to develop tests for the selection of gunners. In time, the detachments were consolidated into Psychological Research Detachment (Gunnery), which worked in close affiliation with the Instructors School. The mission of psychological research was broadened to include studies directed toward the improvement of training, and somewhat later, the work was assured of some permanence by the establishment of Psychological Research Unit No. 11. The mission of this unit was stated broadly as follows:

> To conduct research on psychological aspects of problems having to do with improving the effectiveness of flexible gunnery training methods and increasing efficiency of performance of the gunner.

This statement serves well as a definition of the objectives of pschological research in gunnery throughout the war. Other types of research and developmental activities in gunnery were initiated by mathematicians, physicists, engineers, writers, artists, and gunnery experts who were assigned to the Instructors School. In the last year of the war, the activities of all research and developmental personnel at the newly organized Central School for Flexible Gunnery were combined into one organization which was designated the Research Division. The viewpoint is advanced that psychologists played an important role in providing orientation for much of the work of the various technical groups in the Research Division.

TABLE 4.1.—*Organizations outside of aviation psychology program with which gunnery psychologists cooperated in research and developmental work*

Organization	*Nature of work*
1. NDRC, University of Wisconsin Project, Laredo.	Experimental work on the design of flexible gunnery equipment.
2. NDRC, California Institute of Technology Project.	Development and evaluation of the Firing Error Indicator.
3. NDRC, Voice Communication Laboratory, Waco, Tex.	Preparation of instructional materials on use of interphone.
4. NDRC, Applied Mathematics Panel, Columbia University.	Development of rules for support fire, and similar problems.
5. NDRC, Statistical Research Group, Columbia University.	Experiments on bullet dispersion and evaluation of sights.
6. NDRC, Airborne Fire Control Committee.	Planning for new sighting equipment for gunnery.
7. NDRC, Radiation Laboratory Massachusetts Inst. of Technology.	Evaluation of radar equipment and trainers.
8. NDRC, Franklin Institute, Philadelphia, and University of Tex.	Selection and training of gunners for sight evaluation experiments.
9. Operational Analysis Sections, various combat theaters.	Exchange of information on gunnery tactics and techniques.
10. AAF School of Applied Tactics, Orlando Army Air Base, Fla.	Development of sighting doctrine and evaluation of B-29 trainer.
11. AAF Proving Ground Command, Eglin Field, Fla.	Studies of gunnery equipment, principally of sights.
12. AAF First Motion Picture Unit, Culver City, Calif.	Development of training films.

13. AAF Training Aids Division, New York City.	Publication of Gunner's Information File, phase checks; evaluation of training devices.
14. U. S. Navy Free Gunnery Standardization Committee.	Preparation of instructional materials and evaluation of training devices.
15. Commercial companies	Development of training devices, such as the Jam-Handy (E-14) Trainer, the Waller Trainer.

CHAPTER FIVE

The Nature of Gunnery Proficiency

Lt. Arthur L. Irion

INTRODUCTION

In view of the fact that the flexible gunnery training program was oriented toward the objective of producing gunners who were as proficient as possible, a considerable amount of thought and effort and numerous formal studies were devoted to the problem of defining the concept of flexible gunnery proficiency. These attempts generally fell within three major categories: attempts to describe the tasks of various of the combat gunners, attempts to analyze the tasks of gunners in terms of the requisite abilities and behavioral qualities, and attempts to measure proficiency directly through the establishment of some quantitative criterion of gunnery proficiency.

In order to determine the effectiveness of either a selection or a training program, a measure of gunnery proficiency in terms of some criterion score was necessary. The ideal procedure for the establishment of a selection or a training program would require the simultaneous development of a criterion and of selection and training procedures, followed by the validation of the latter in terms of the former. In practice, as a result of military necessity, it proved to be necessary to select and train gunners before establishing a criterion. Therefore, the use of job descriptions and ability analyses for the purpose of setting up selection and training procedures was of more importance than the validation of these procedures against a proficiency criterion. The war was terminated before any large scale validation experiments had been conducted.

ATTEMPTS TO DESCRIBE THE GUNNER'S TASK

The flexible gunnery program suffered to a marked degree in its early days because of the lack of systematic and accurate descrip-

tions of the tasks gunners were required to perform in combat. This deficiency was gradually corrected by a number of carefully planned and accomplished job descriptions. One of these which was felt to be most effective was made on B-29 gunnery in the 20th Bomber Command.[1] This study provided an accurate and detailed picture of the combat activities of B-29 gunners.

Job Descriptions

Typical methodology involved in making job descriptions.—The following procedures were used in studying the activities of gunners in the 20th Bomber Command:

1. Observations were carefully made and then checked with competent personnel. This procedure served to correct inaccuracies which might have been recorded as a result of unchecked observation, while also serving the practically useful function of indicating areas in which the 20th Bomber Command personnel were reacting to verbalisms rather than to actual behavior of gunner personnel.

2. B-29 combat operations were studied in detail. All pertinent publications, such as Tactical Doctrine and Mission Reports, were studied and discussed with staff officers of the Bomber Command. Careful notes were taken at critiques of missions. All observable phases of a combat mission were studied first hand by flying missions as a gunner.

3. Carefully constructed questionnaires were personally administered. These questionnaires covered the activities of bombardiers, gunners for each sighting station, computer maintenance men, general maintenance men, armament men, gunnery officers, and armament officers. The questionnaires were constructed so that the results would establish who did each job and how each task was accomplished. All answers to questions were obtained by personal interview.

4. Observations were made and agreement reached for all jobs all levels and were finally confirmed at Command Headquarters before the report of job description was made.

Activity lists.—Under the procedures outlined above, lists of specific activities were prepared for each type of B-29 gunner. For example, the following list of activities was prepared for the B-29 career gunner.

The B-29 career gunner must be able to:

1. Track and frame smoothly and accurately with his specialized sight.
2. Trigger correctly.
3. Turn on switches in his sighting station correctly.
4. Transfer control of turrets at the proper time without damaging other B-29's.

[1] This study was conducted by Maj. Robert Bragarnick, in December 1944.

5. Use standard interphone procedure.
6. Search properly.
7. Identify Japanese fighters and set their wingspans into the sight.
8. Identify types of surface vessels and report their position, course, and speed.
9. Clean and adjust his caliber .50 machine gun.
10. Load the guns in his assigned turret.
11. Perform an operational check of his assigned sight, turret, and guns.
12. Perform a preflight inspection of his assigned sight, turret, and guns.
13. Perform an inflight check of his assigned sight, turret, and guns.
14. Clear his guns.
15. Stow his guns properly for takeoff and landing.
16. Use his personal equipment properly.
17. Determine if his oxygen mask is in good condition and fits properly.
18. Determine if the oxygen bottles are ready for a flight and fill walk around bottles in flight.
19. Determine if his parachute and Mae West are in good condition.
20. Mount a gun camera, load it, make the necessary settings, and take pictures at the proper time.

Lists were also prepared of things that each gunner had to know. It was reported, for example, that:

The B-29 career gunner must know:

1. The areas of search and zones of fire of each gunner on the airplane.
2. How changes in formation affected the areas of search and zones of fire for each gunner.
3. What to do in the event it was necessary to bail out.
4. What to do in the event that it was necessary to ditch.
5. What length of burst to use at all ranges and in all positions.
6. Elementary first aid.

Lists, similar in nature to the activity lists for B-29 gunners, were prepared for other types of gunnery. For example, early in 1944, the duties and necessary skills of gunnery officers in the 8th Air Force were described, as well as the tasks of basic gunners operating in that Air Force. A later study was made of the duties of A-26 gunners in the 9th Bombardment Division of the 9th Air Force.[2]

In general, these descriptions of the duties of gunners were similar, in that they embraced the following areas of performance:

1. A preflight inspection and operational check of equipment, including guns, turrets, and sighting equipment.
2. The loading of ammunition into the turrets.
3. The operation of gunnery equipment in the event of enemy fighter attacks.
4. A postflight inspection of equipment.
5. The cleaning, oiling, and adjusting of guns.
6. Crew-member activities, such as interphone, bailing out, ditching, first aid, and use of parachute, oxygen equipment, and heated clothing.

Most of the gunner's time and energy, these studies revealed, was spent in caring for his equipment and making it ready for combat use.

Descriptions of incidental conditions of work.—For many jobs it is desirable that the conditions surrounding the job also be de-

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[2] The 8th Air Force Study was made by Maj. Roger W. Russell. The 9th Bombardment Division study was made by Capt. John A. Valentine and Lt. Frank J. Harris.

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scribed, if the job description is to be of most value in the setting up of a criterion situation or of an appropriate training or selection program. This factor often tended to be overlooked in studies of combat duties, but efforts were made to include it. One study, for example, provided a description of the conditions under which gunners lived and worked in the China-Burma-India Theater of Operations in the spring of 1944.[3] This description dealt with specific problems such as living conditions, food, personal conveniences, climate, and the living conditions of the native populations; all in considerable detail. Although many of these observations could not find direct incorporation into a training program, some of the findings were of value. For example, in some of the bases in this theater, conditions of extreme dustiness alternating with dampness prevailed. This climatic condition caused corrosion and rust, especially to the moving parts of the caliber .50 machine gun. Corrective education for this condition was therefore incorporated into the gunnery training program.

Descriptions of Individual Characteristics Important in Gunnery Performance

As a result of the accomplishment of job descriptions under the procedures listed in the preceding section, several attempts were made to make generalizations regarding the qualities which were necessary or desirable for the gunner to possess. In the absence of a criterion situation in which gunnery proficiency could be measured directly, and as a first approximation in the construction of a battery of selection tests, an analysis of the gunner's task in terms of abilities which the gunner had to possess to perform it adequately was a necessity.

One attempt to arrive at such a list of behavioral qualities involved the judgment of gunnery officers in various combat air forces regarding the minimum acceptable standards for enlisted aircrew members with respect to the abilities which were presumably measured by the aviation cadet selection and classification battery.[4] These officers were given the list of abilities, each ability being accompanied by a descriptive phrase, and asked to assign the minimum acceptable amount of ability for each item, on a nine-point scale. This scale was arranged with 9 as "exceptional," 7 as "very much better than average," 5 as "better than

[3] This study was made by Capt. Wilbur S. Gregory.

[4] These studies were carried out in the 8th Air Force by Maj. Roger W. Russell, in the 7th Air Force by Capt. Mason Haire, in the 5th and 13th Air Forces by Lt. Alfred C. Jensen, and in the CBI by Capt. Wilbur S. Gregory. Lt. William B. Schrader collated the data from the individual studies. Some of the procedures for the studies, particularly the method for defining standards, were developed by Col. John C. Flanagan (see report No. 17 of this series).

average," 3 as "average enlisted man," and 1 as "worse than average."

The list of behavioral qualities, together with the defining statements which were presented to the rating officers, is presented below.

1. *Judgment.*—Ability to make sound judgments and choices as to the best thing to do when faced with a practical problem.

2. *Mechanical comprehension.*—Ability to understand and interpret the operation of mechanical devices.

3. *Arithmetic reasoning.*—Ability to solve quantitative problems expressed in verbal form.

4. *Arithmetic calculations.*—Speed and accuracy in adding, subtracting, multiplying, and dividing simple numbers.

5. *Mathematics.*—Skill in the use of algebraic formulae and other simple mathematical tools.

6. *Reading comprehension.*—Ability to understand and grasp the meaning of general and technical descriptions in written form.

7. *Memory.*—Ability to remember specific and detailed information.

8. *Dial and table reading.*—Speed and accuracy of obtaining specific information from dials and tables.

9. *Visualization of the flight course.*—Ability to visualize the course of the plane with reference to the horizon and fixed or moving reference points such as other planes.

10. *Estimation of speed and distance.*—Ability to make estimates of speed, distance, and altitude in relation to the flight of the plane.

11. *Orientation and observation.*—Ability to find his correct geographic position by identifying the area below by comparison with maps and photographs.

12. *Division of attention.*—Ability to remain alert and observant of other things while the principal attention is directed to a specific activity.

13. *Speed of decision and reaction.*—Ability to think quickly, to make rapid decisions, or to respond with speed and precision when the situation demands.

14. *Serial reaction time.*—Ability to execute a series of simple movements rapidly and accurately.

15. *Coordination.*—Skill in making appropriate movements with the hands or feet to accomplish a specific task.

16. *Finger dexterity.*—Deftness in making fine adjustments or movements with the fingers.

17. *Emotional control.*—Ability to remain cool and collected

and to think and act without interference from anxiety and emotion when faced with an emergency or a difficult situation.

18. *Motivation.*—Interest in combat aviation and desire to fly and to be as effective as possible in doing the tasks assigned.

19. *Dependability.*—Willingness to assume complete responsibility for carrying out all jobs assigned in an effective manner.

20. *Leadership.*—Ability to inspire confidence, pride, and loyalty in men and to develop cooperation and a "team spirit."

The mean minimum qualification ratings given by the gunnery officers in various combat air forces are presented in table 5.1.

TABLE 5.1.—*Minimum qualifications of gunners in 20 traits as judged by experts in gunnery in various theaters (first half 1944)*[1]

	8th AF (N=25)	5th, 13th AF (N=63)	7th AF (N=11)	14th AF (N=9)	Mean (N=108)
1. Judgment	4.9	6.0	5.3	6.3	4.9
2. Mechanical comprehension	5.2	4.9	5.8	8.0	5.2
3. Arithmetic reasoning	3.4	3.6	3.2	4.3	3.4
4. Arithmetic calculations	3.6	3.7	3.0	4.6	3.6
5. Mathematics	3.2	3.0	3.1	4.3	3.2
6. Reading comprehension	4.4	4.5	4.2	5.1	4.4
7. Memory	5.2	5.6	5.6	5.9	5.2
8. Dial and table reading	3.7	4.2	4.4	5.6	3.7
9. Visualization of the flight course	5.0	5.5	5.0	6.3	5.0
10. Estimation of speed and distance	5.0	5.3	5.0	6.3	5.0
11. Orientation and Observation	3.7	4.5	3.4	5.7	3.7
12. Division of attention	5.4	5.8	6.2	6.8	5.4
13. Speed of decision and reaction	5.5	6.7	6.6	7.4	5.5
14. Serial reaction time	5.0	5.8	6.3	7.0	5.0
15. Coordination	5.2	5.9	6.6	7.1	5.2
16. Finger dexterity	4.1	5.0	5.4	6.2	4.1
17. Emotional control	5.8	6.5	6.4	7.8	5.8
18. Motivation	5.8	6.2	6.4	7.4	5.8
19. Dependability	5.4	6.7	6.9	7.0	5.4
20. Leadership	4.4	6.4	5.4	6.7	4.4

[1] All ratings made on a 9-point scale with mean point defined as 5.

It will be noted that these ratings show a considerable degree of consistency. This is further indicated by the intercorrelations of the ratings as given in the different air forces, which are presented in table 5.2.

TABLE 5.2.—*Intercorrelations among judgments of minimum qualifications of gunners in each of 20 traits by experts in 4 theaters of operations. (First half, '44)*

	Number of judges	8th Air Force	5th and 13th Air Force	7th Air Force	14th Air Force
8th Air Force	25		0.87	0.90	0.87
5th, 13th Air Force	63	0.89		.90	.94
7th Air Force	11	.91	.90		.92
14th Air Force	9	.87	.94	.92	

The results would seem to indicate that gunnery officers consistently considered the qualities represented by the items of Emotional Control and Motivation to be of the most importance, or, at least, that a higher degree of these qualities was considered neces-

sary than in the case of other items. It will be noted that Speed of Decision and Reaction, Division of Attention, and Dependability, as well as several other items, also received relatively high ratings.

There was one difficulty with the study which should be kept in mind in interpreting the results. Certain of the qualities listed, notably those designated as "motivation," "emotional control," "dependability," and "leadership," were defined in fairly general and elusive terms. The descriptions did not incorporate references to specifically observable behavior. Since the descriptions were not pinned down definitely to specific behavior on the part of the gunner, and since the possession of such qualities is generally considered good and desirable for almost any job, one might well expect the judging officers to have given most favorable ratings to these items. Thus, higher ratings may possibly have been given on these items than was rigorously demanded by the gunner's job. However, the emphasis which the gunnery officers placed upon Emotional Control and Motivation did point up a selection need which had previously received inadequate attention.

A Rational Analysis of the Firing Task

Another approach to the problem of determining what the gunner had to do in order to be successful involved the careful observation and analysis of his firing task for the purpose of describing the types of psychological activity in which the gunner had to engage in order to perform his task. One such study involved a rational analysis of the gunner's task into four major divisions, two of which were concerned with such descriptions.[5] The first of these two divisions was concerned with factors predominately perceptual in nature, and included such portions of the gunner's task as had to do with the estimation of deflection, the estimation of range, the estimation of the gunner's own position in space, the estimation of framing accuracy, and the peripheral perception of movement. The second division was concerned with psychomotor aptitudes and included consideration of problems involved in coincident tracking, wherein the gunner needed only to keep his sight directly on the target; displaced tracking, in which the gunner had to track with his sight somewhat displaced from the target; direct-control tracking, which involved the pointing of the guns by hand; and remote-control tracking, which involved the pointing of the guns through manipulation of turret controls. Also considered in this division were the problems of framing control, and

[5] This study was accomplished by Capt. Judson S. Brown of the AAF School of Aviation Medicine and Capt. Mason Haire.

combinations of such factors as tracking and framing, and tracking, framing, and triggering.

The various subdivisions of the gunner's task as conceived in this manner were dealt with in considerable detail, and suggestions were made regarding appropriate tests which might be administered for the selection of gunners.

THE MEASUREMENT OF GUNNERY PROFICIENCY

Fundamental research in the selection and training of flexible gunners was larely dependent upon the establishment of criteria of gunnery proficiency, and the worth and validity of research in these fields was limited by the adequacy of the criteria which were available. The selection problem resolves, in its simplest form, to the problem of determining which of various potential selection devices yield scores which correlate most highly with the criterion scores. Similarly, research in training reduces to an experimental determination of the training methods which cause the greatest increase in criterion scores. In either case, adequate measures of proficiency are essential to the accomplishment of the research. It was necessary therefore, to give operational meaning to the term "gunnery proficiency."

The Criterion Problem in Gunnery

A definition of objectives.—A criterion of flexible gunnery proficiency had to be defined in terms of the objectives of flexible gunnery as well as in terms of the procedures employed in setting up the criterion situation.[6] The former problem was a relatively simple one, in that it was comparatively easy to list the desired consequences of a gunner's behavior. In its utmost simplicity, this objective was described in terms of the gunner's ability to protect his bomber and his formation from enemy fighters, either by destroying them or by driving them away. It was not, of course, implied that the gunner's task was confined to the accomplishment of this single objective. Yet, without being entirely comprehensive, the definition did outline the essential part of the gunner's task, the portion of it which was uniquely his province and which was his military *raison d'etre.* If it is recognized that a definition, such as the one stated above, was not entirely comprehensive, there is likely to be little objection to such a formulation.

The latter definition of a criterion, that of describing the conditions under which it is established, was more difficult to make.

[6] The general problems of criteria of proficiency are discussed in detail in report No. 3 of this series.

The remainder of this chapter will be devoted to a discussion of such procedures.

The desirable characteristics of a criterion score.—The establishment of a criterion situation should be such that it eventually yields for each individual a mathematical value which denotes the degree to which the individual fulfills the requirements imposed by the initial statement of objectives. It is, moreover, desirable that this mathematical value possess certain qualities which render it an adequate measuring instrument. If possible, the criterion scores should lie along an extensive scale which has a zero point. More importantly, the scores should possess the quality of reliability. In addition to these qualities, the criterion scores should be practically obtainable, within the limits of the sources afforded to the research worker. Lastly, the criterion scores must be obtained in a valid situation.

The problem of criterion validity.—It seemed obvious that the most valid test of a gunner's proficiency lay in the combat situation. It was for this situation that the gunner was selected and trained, and it was against his success in combat that the efficacy of the devices which selected him and the methods which trained him should most desirably have been judged. In actuality, however, it was not possible to obtain a combat score of high validity. There were numerous reasons for this, the most important being that too many extraneous factors entered into the combat situation to allow the scores which were obtained therefrom to be reliable. A gunner's success or failure in combat depended not alone upon his own skill, but rather, in a large measure, upon the proficiency of others, both friend and foe. These, and other extraneous factors, served to lower the reliability of scores obtained in the combat situation, which in turn had the effect of limiting the validity of whatever measures were taken.

Substitute criteria.—In the absence of a suitable combat criterion, the only alternative involved the setting up of situations which were highly similar to combat and which were, at the same time, subject to control. These situations had to be as realistic as possible in terms of the demands which they made upon the gunner, yet they had to lend themselves to the taking of measurements which reflected the essential aspect of the gunner's task. The setting up of such alternate situations involved the judgments of gunnery experts as to the actual degree of similarity which might exist between the criterion situation and combat, for it was obvious that the two situations could not be made to be identical. These ex-

perts had to determine, on a subjective basis, the apparent validity of the alternate criterion situation.[7]

In the construction of a substitute criterion, job descriptions of the gunner's job in combat were useful, in that they gave the gunnery expert some objective method of checking the apparent validity of the criterion situation. There were, however, limitations to the use of job descriptions in this connection. To construct a criterion situation solely upon the basis of a description of current job procedures would have been to run the risk of preserving a traditional method of job accomplishment which might not have been adequate to the needs of the situation. Instead, what was required, more than a description of how the individual gunner performed his task in combat, was a detailed description of the conditions under which he worked. In flexible gunnery, for example, it was important to know the number and type of enemy aircraft likely to be encountered, the habitual tactics of the enemy, the characteristics of the gunner's aircraft and equipment, the length of the gunner's missions, the amount of support the gunner received from fighter escort, and so on for the many factors which determined for the combat gunner the conditions under which he had to operate. In the past, the technique of job description has been of greatest value in obtaining this type of information, yet the limitations of the techniques should be recognized by the research worker.

Necessary assumptions in the establishment of a substitute criterion.—The establishment of a substitute criterion becomes a task of great complexity unless it is recognized that there was one central factor in the accomplishment of the objectives of flexible gunnery. This central factor was the gunner's proficiency in aiming and firing his guns. However, this main division of the gunner's job was surrounded by numerous contributory factors. In order that the gunner might be able to aim and fire his guns adequately, he had to possess a number of other skills, abilities, and characteristics. For example, he had to be able to care for, adjust, and maintain his equipment. He had to have the ability to withstand the stresses of combat. These and many other factors contributed to the final effectiveness of a gunner, yet to construct a criterion situation which would have assessed all of them simultaneously would have been impossible. For the present, therefore, the central factor only shall be considered, this being the factor which belongs uniquely to the gunner. At the

[7] Apparent validity is a term which is used to describe the amount of similarity between the test situation and the situation being tested for, in so far as this similarity is apparent to a qualified observer.

end of the chapter the problem of assessing contributory factors will be discussed.

Attempts to Obtain a Criterion of Firing Proficiency Through the Use of Synthetic Training Devices[8]

The Waller Trainer.—The Waller Trainer was a synthetic training device which involved the firing of similated hand-held and turret-mounted guns at moving picture photographs of attacking aircraft. There were four gun positions for each trainer. The pictures, which were projected from multiple projectors onto a large, semi-sperical screen, were actual photographs of attacking aircraft taken in flight. The hand-held guns were equipped with devices which simulated recoil when the triggers were depressed. The gunner wore earphones through which he heard simulated aircraft and gun fire noises.

The apparent validity of the Waller Trainer was limited by several factors. Being a ground installation, it suffered loss of realism, as did all other ground installations. The attacks in the Waller Trainer were more limited in scope than those found in combat because of the limitations of the size of the screen. The reliability of the trainer was affected by deficiencies in its scoring system. It was observed that differences in difficulty existed between various of the gun positions, which differences could not be completely controlled or corrected (see p. 165). Coefficients of reliability of scores on the Waller Trainer under experimental conditions clustered around 0.75. Under normal conditions of operation in training, reliabilities fluctuated and were generally much lower than those obtained in experimental work (see p. 163). These considerations limited the usefulness of the Waller Trainer as a criterion of firing proficiency. Potentially, however, the Waller Trainer was considered to be the most promising of the synthetic trainers, except for B-29 gunnery. Although it was used in several studies of learning, the Waller Trainer was not used for the validation of selection tests due to inadequacies in film available at the time such studies were underway.

The Jam-Handy (E–14) Trainer.—This device was another type of motion picture trainer. It was less elaborate than the Waller Trainer in that it involved only two projectors and a single gun position for each trainer. The screen on which the pictures were projected was much smaller than the Waller Trainer screen and was a plane rather than a curved surface. Student performance on the Jam-Handy (E–14) Trainer was scored on the basis of subjective judgments of the instructor, who was provided with several aids for scoring. The reliability of the scores obtained by

[8] For a more detailed description of synthetic training devices, see chapter 9.

this method was quite satisfactory if the conditions of administration were rigidly controlled. One study yielded reliabilities of .80 (see p. 171). A mechanical scoring device was later developed, but no data on the performance of this scoring unit are available. The apparent validity of the Jam-Handy (E–14) Trainer was low as compared with the Waller Trainer. The small size of the projection screen prevented the realistic presentation of attacks other than nose attacks, tail attacks, and quarter attacks from either the nose or tail, which were the easiest forms of attack for the gunner to handle.[9] The pictures in the Jam-Handy (E–14) Trainer were of model planes manipulated against a painted background. Although the effect produced by this process was quite good, it was not as effectively realistic as the photographs of actual planes used in the Waller Trainer. The Jam-Handy (E–14) Trainer suffered from being a ground rather than aerial installation. Also, the gunner's score was reached through the use of a mathematically computed aiming point which might have been subject to errors. Though the Jam-Handy (E–14) Trainer was considered less satisfactory than the Waller Trainer as a criterion of firing proficiency, it was used to advantage in several studies of the validity of selection tests (see chapter 6), and of proficiency of gunners (see chapter 11).

The Hobson-Strnad Trainer.—The Hobson-Strnad Trainer was developed to provide practice for B–29 gunners in the manipulation of the B–29 pedestal sight. This trainer incorporated many desirable features of a ground trainer. The target consisted of a silhouette which could be made to simulate the appearance of an attacking fighter, both with reference to its apparent closing and its changes in attitude throughout the attack. Since these changes were accomplished mechanically, it was possible to correlate the apparent position of the target with the operation of the sight in such a fashion that a score could be obtained which would indicate the amount of time that the gunner was correctly tracking and framing the target. A refinement of the basic scoring system consisted of a polygraph by means of which the gunner's performance in azimuth tracking, elevation tracking, framing, and triggering could be recorded. This trainer was developed during the final months of the war, and no data were obtained from which the reliability of scores might be estimated. However, it appeared that the Hobson-Strnad Trainer had most

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[9] In practice, beam attacks were presented in the Jam-Handy (E–14) Trainer, by panning the background. This process produced the visual impression of a beam attack, but the tracking of such an attack was much more simple than the tracking of an actual beam attack since the total tracking angle was much smaller and the rate of tracking was correspondingly slower.

of the characteristics of a satisfactory substitute criterion situation, for B-29 gunnery.

Attempts to Obtain a Criterion of Firing Proficiency Through the Use of Ground Firing Ranges[16]

The Moving Target Range.—The Moving Target Range required that the gunner fire hand-held and turret-mounted machine guns at a cloth target which moved about a large oval track. The near side of the track was approximately 200 yards in front of the gunner and the far side of the track was approximately 400 yards distant from him. The gunner's score was obtained by counting the number of holes in the target. While this situation introduced the realistic element of firing the guns, and while the scoring took place in terms of the actual effects of gunfire produced by the gunner, the situation was quite unrealistic in terms of other conditions. Tracking was limited to the azimuth dimension only, and the deflections required of the gunner were not those which were required in the combat gunnery situation. The target moved at a slow relative speed, giving the gunner a leisurely and unrealistic firing situation. The reliability of scores obtained on the Moving Target Range was about .70 (see p. 205). Primarily because of its lack of apparent validity, the Moving Target Range did not meet the requirements of a criterion of firing proficiency. In the absence of a more acceptable criterion, however, it was used in several attempts to validate tests for the selection of gunners (see chapter 6).

The OQ-3 Range. The OQ-3 Range involved the use of small radio-controlled target aircraft which were fired upon from ground gun positions. The target planes had a wingspread of 12 feet and could develop speeds in excess of 100 miles per hour. These planes were flown by remote radio control in such a manner that they simulated attacks upon the ground gun positions. The gunner attempted to shoot down the attacking targets, using standard turret-mounted equipment. The OQ-3 Range attacks lacked validity for the flexible gunner because there was not the factor of the gunner's own forward speed to be compensated for. Practice on such a range represented practice in anti-aircraft gunnery rather than flexible gunnery. Even with sights modified especially for the range, the firing situation was unrealistic. Further, the target aircraft was so small that only a minute proportion of the bullets fired actually struck it. For example, during one study only 4 percent of the rounds expended were reported as hits (see p. 217). No determination of the reliability of scores

[16] For a more detailed description of ground ranges, see chapter 9.

obtained on the range was made. In consideration of the extremely low mean percent of hits and many uncontrollable factors in the operation of the range, it was unsafe to assume satisfactory reliability of OQ-3 Range scores. The OQ-3 Range was not used as a criterion of gunnery proficiency.

The Poorman Range.—The Poorman Range combined several of the features of a firing range and a synthetic trainer. In aerial combat, a gunner was required to rotate his turret so that the guns were kept pointing in the direction of the attacking fighter. In the Poorman Range situation, the gunner's target remained stationary, but the platform upon which the gunner's turret was mounted rotated. This made it necessary for the gunner to rotate his turret in the opposite direction to compensate for the movement of the base and to keep his guns pointed to the target. In doing this perfectly, the gunner kept his guns absolutely motionless. While the gun platform rotated, the model airplane, which served as a target for sighting, simultaneously moved toward the gunner with a sufficient degree of lateral movement to make changes in deflection necessary. The gunner had to sight the model plane, giving it the correct deflection in order to keep his guns stationary. The gunner fired at a stationary cloth target which was behind and below the model plane. If the gunner was sighting and firing correctly, his bullets would pass through the center of this target. But if the gunner was not sighting correctly, he would not compensate for the rotation of his turret mount and his bullets would no longer pass through the center of the cloth target.

There were several deficiencies of the Poorman Range situation when considered from the standpoint of a gunnery criterion. For one thing, there were several ways in which the gunner could "beat the game" by making his task simpler than it should be. He could do this by employing cues other than the model target plane for keeping his turret stationary. In addition to this defect, the Poorman Range situation did not allow for tracking in elevation. Since the gunner in combat almost never received an attack which might be tracked either purely in elevation or purely in azimuth, this deficiency represented a considerable simplification of the gunner's actual problem. In one study, a reliability of 0.56 was obtained for Poorman Range scores (see p. 210). Under carefully controlled conditions, the Poorman Range might have been a fairly satisfactory criterion of firing proficiency. However, the range was not widely enough used to permit its use as a criterion, except for very limited studies.

Miscellaneous ranges.—There were numerous other ranges used in the training of flexible gunners. These included the Skeet

Range, the Giant Skeet Range, the High Tower Range, the Moving Base Range, the Full Scale Range Estimation Range, the Burst Control Range, and others. None of these ranges was considered sufficiently representative of the gunner's shooting job to warrant its use a criterion of firing proficiency. However, in several instances some of these ranges were used in studies of selection tests (see chapter 6) and in other experimental work (see chapters 9 and 11).

Attempts to Obtain a Criterion of Firing Proficiency Through the Use of Aerial Training Situations [11]

Air-to-air firing.—Air-to-air firing was the traditional air training situation for flexible gunners. The gunner was required to fire machine guns, using standard equipment, against some form of flag or sleeve target towed by a second aircraft. This target was typically towed in a course parallel to the line of flight of the firing aircraft. It was possible to introduce some degree of relative speed into the situation by towing the target either faster or slower than the firing aircraft. It was not possible, however, to tow the target in a simulated attack course. This situation possessed considerable realism in that the gunner and the target were both air-borne, and the gunner used typical gunnery equipment. The course of the target relative to the gunner was, however, quite unrealistic and presented a type of deflection problem which the gunner would seldom, if ever, encounter in combat. The reliability of air-to-air firing scores was very low, under typical gunnery school conditions. In one study, most of the coefficients found were below .50 (see p. 218). This was probably due in part to the fact that the target was too small to catch any but a small percentage of the bullets fired at it; consequently the assessable sample of the gunner's behavior was exceedingly small. Conditions of operation were also difficult to control. For these reasons, the air-to-air firing situation was unsuitable for use as a criterion of firing proficiency. It was used, however, in many of the early studies of the validity of proposed selection tests (see chapter 6).

The Firing Error Indicator.—The Firing Error Indicator was an electronic device which consisted of a small radio transmitter which could be mounted in an aerial target and a receiving unit which was typically mounted in the gunner's aircraft. The transmitter was equipped with microphones which detected the audio shock waves initiated by projectiles passing in the vicinity of the target. This had the effect of creating a sensitive, nonmate-

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[11] For further information on air training devices and procedures, see chapter 9.

rial target zone about the transmitter. By making adjustments in the transmitter, the size of the sensitive zone could be varied somewhat, and could be extended 30 or 40 yards on either side of the transmitter. The receiving device was equipped with counters which recorded the number of projectiles passing within the sensitive zone and which indicated whether the projectiles passed to the right or left of the aiming point. The Firing Error Indicator, therefore, overcame one of the deficiencies presented by material aerial targets in that it allowed the size of the target to be increased without effect upon the realism of the size of the aiming point. In addition to being mounted in a flag or sleeve type target, the Firing Error Indicator was mounted in two types of rigid targets, a bomb-like structure and a glider target. Mounted in either of these fashions the Firing Error Indicator was flown in simulated attack courses, thereby overcoming another of the deficiencies presented by the traditional air-to-air firing situation. As mounted in the glider target, the Firing Error Indicator situaton possessed a high degree of realism.

Unfortunately, the Firing Error Indicator, at the stage of development reached during the war, did not represent an ideal solution to the problem of firing proficiency. Mechanical and electronic unreliability of the apparatus created difficulties. It was difficult to control the size of the target zones precisely. The size and shape of the zones showed variations from transmitter to transmitter and within a single transmitter from time to time. There was also a lack of symmetry of the zones, which tended to influence the scoring. No statistical estimate of the reliability of scores on the Firing Error Indicator is available. The reliability would be expected to be low with the equipment used in the exploratory tests of the device. With more refined equipment, which was developed but not fully tested, the full potentialities of this promising aerial target might have been realized.

The Frangible Bullet Trainer.—The Frangible Bullet Trainer represented another potential criterion of firing proficiency. It consisted of a specially adapted caliber 0.30 machine gun, special ammunition which shattered upon contact with armor plate, and a specially armored pursuit ship. The frangible projectile was constructed of a material which was sufficiently cohesive to allow the projectile to be fired, yet which was breakable enough so that it would shatter upon striking armor plate. The armored pursuit ships flew attacks against which the gunner fired, using the special guns and ammunition. Hits were recorded by an electronic apparatus within the fighter. Despite a promising amount of realism, there were certain defects which tended to render the situation unsuitable for use as a criterion of firing proficiency.

The basic difficulty was the reduction of the muzzle velocity of the frangible projectile to 1,350 feet per second, or one-half the muzzle velocity of the caliber 0.50 projectile. This lowered speed of the projectile necessitated a revision of the deflection problem from the gunner's standpoint. Deflections required were different from those required for firing in combat. Sights had to be adjusted to compensate for these differences in required deflection, and an undetermined amount of distortion of the gunner's problem was introduced.

In addition to these difficulties, the scores obtained on the Frangible Bullet Trainer were relatively unreliable. As in the traditional air-to-air firing situation, too small a proportion of the gunner's bullets were recorded as hits. For example, in one study the mean percentage of hits was 3 percent (see p. 244). Reliable scores could be obtained in this situation only with a tremendous amount of firing. Single mission reliabilities of 0.07 were typical, although reliabilities as high as 0.50 were obtained by combining data from 18 missions (see p. 244). These factors limited the usefulness of the Frangible Bullet Trainer situation as a criterion of firing proficiency. The trainer was not used as a criterion in any research studies.

The gun camera.—The gun camera was a device by means of which a gunner took pictures of his aiming point instead of shooting bullets at it. The gun camera was installed in a standard gun position. Fighter aircraft flew attacks against the gunner's ship. The gunner "fired" at them with the camera gun, just as he would do if he were using real ammunition. Various devices existed for determining where the gunner's aiming point should be if he were aiming correctly. When noncomputing or noncompensating sights were used, a determination of the aiming error was made by measuring the distance from the theoretically correct point of aim to the gunner's actual point of aim as indicated on the gun camera film. This type of assessment rested upon the assumption, of course, that the computed point of aim was actually correct, an assumption which may not have been fulfilled in all cases. In the case of computing or compensating sights, the gun camera was mounted so that the pictures were taken through the optic head of the sight. In such cases, the film was assessed, not in terms of the gunner's ability to hit the attacking aircraft, but in terms of his ability to manipulate the sight correctly. The assumption was made that if the gunner were operating the sight correctly, as indicated by the gun camera film, he was getting "hits" on the target, and his proficiency was assessed accordingly.

From the gunner's standpoint, the assumption of the validity of the equipment was the fairest one to make. The gunner could

not be expected to be more proficient than the equipment he was given. A more accurate statement of the objective for this situation would have been that the gunner was to operate his equipment in the manner indicated by the instructions given to him for its use.

Several deficiencies in the gun camera situation did exist. For one thing, there was no actual firing of the guns. This involved a different psychological situation from the situation in which the guns were actually fired, and constituted a real, although perhaps not serious, loss of realism. Attempts to remedy this loss by the firing of blank ammunition were never entirely successful, although this possibility should be considered in evaluating the camera gun situation. A more serious objection was that gun camera missions, like combat missions, were exceedingly difficult to control. This resulted in a lowering of the reliability of the scores obtained on gun camera missions, since it was difficult to present a gunner with the same task on successive missions (see pp. 222–230 for a detailed discussion of the complex problem of reliability of gun camera scores). This lack of score reliability was emphasized by the small sample of behavior which was typically taken, both with respect to the number of gun camera missions flown and with respect to the amount of firing accomplished on each mission per gunner. It should be noted that the reliability of scores obtained within a mission was typically higher than the reliability of scores obtained between two different missions. The lack of score reliability did not affect group means on gun camera performance to the extent that individual scores were affected. Consequently, the camera gun was considered to be of greater value as a group than as an individual criterion of firing proficiency. One other deficiency of the gun camera situation was that much of the film which was exposed was not clearly enough defined for scoring purposes. This photographic deficiency made it difficult to obtain comparable film records for a group of gunners. Film which was poorly exposed or which was spoiled in development could not be made up in an experimental situation without introducing an additional variable of uncontrolled practice. Notwithstanding these deficiencies, the gun camera situation, if controlled with the greatest care, was considered to be the most adequate single criterion of firing proficiency which was available. It was used as a criterion in several research studies, reported in chapters 6 and 9.

Conclusions

1. Scores derived from combat could not be used for the purpose of assessing firing proficiency because of the large number of

factors, extraneous to the gunner's proficiency, which influenced the obtained results.

2. In the establishment of a substitute criterion of firing proficiency, it was not possible to determine the validity of the criterion situation directly. Validity had to be estimated by gunnery experts. In making such estimates of validity, carefully worked-out job descriptions of the relevant aspects of the combat situation proved to be of value.

3. In the establishment of a substitute criterion, it was difficult to construct a situation which had a high degree of apparent validity. It was exceedingly difficult to obtain a situation in which the factors of the gunner's own speed, the speed and course of the attacking fighter and the ballistic characteristics of the gunner's weapon were realistically portrayed.

4. Ground situations were easier to control than aerial situations. Hence, the scores from them were more likely to be reliable; yet ground situations typically had less apparent validity than aerial situations.

5. Scores obtained in aerial situations were influenced by many factors which were extraneous to the gunner's ability. These factors tended to lower the reliability of the scores obtained.

6. A number of potential criteria of firing proficiency employed scores which had a theoretical rather than an actual basis. The gun camera and the Jam-Handy (E-14) were examples of this. Scores obtained in these situations were based upon certain mathematical assumptions and computations. They reflected a definition of the gunner's objective in terms of his ability to manipulate his equipment according to instructions given to him rather than in terms of his demonstrated ability to hit the target.

7. In situations which required the gunner to fire his guns at realistic targets, the gunner's problem became so difficult that only a small proportion of hits were recorded. This would be expected to reduce the reliability of the measures taken in those situations. To increase the size of the target was impracticable. What was needed, therefore, was a realistically sized target aiming point surrounded by a nonmaterial target scoring area. This advantage was possessed by two types of devices, the gun camera and the Firing Error Indicator. Of those, only the Firing Error Indicator represented a situation in which guns were actually fired and in which scoring of actual hits rather than of theoretically inferred hits took place. The Firing Error Indicator was, however, less realistic than the gun camera in respect to the target used, and it had mechanical and electronic inadequacies.

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8. The gun camera situation was considered to be the best single criterion available for the assessment of firing proficiency.

Attempts to Obtain a Criterion of Gunnery Proficiency on Subsidiary Skills

Previously in this chapter, emphasis has been placed upon the fact that the gunner's primary job was to shoot effectively. However, there were certain contributory skills which were requisite for the successful accomplishment of the major purpose of the gunner. The gunner was not just a gunner; he was also a gun-mechanic. In order to be able to shoot when attacked by an enemy fighter, he had to have his equipment in perfect working order. Guns had to be cleaned, ammunition checked, turrets loaded, guns and sights accurately harmonized, turrets checked for smooth operation. These were normally the responsibilities of the gunner. The gunner was also a crew member, which meant that he had certain responsibilities for the safety and efficiency of other men in the bomber. He had to be able to use the interphone, he had to know first aid, he had to know emergency procedure, he had to be observant of events and objects which might have intelligence value. Finally, the gunner had to keep himself ready for action. He had to protect himself from cold and from lack of oxygen. He had to be able to use and keep in good condition his personal equipment. These important subsidiary skills of the gunner were measured by achievement tests and by phase checks.

Phase checks.—Phase checks were developed as measures of the gunner's ability to adjust and maintain his equipment. The phase check situation allowed the observation and measurement of behavior under relatively constant conditions. Of all of the measures of any aspect of gunnery proficiency, the phase checks possessed the highest degree of apparent validity. The phase check, moreover, did not assess a small sample of behavior but included all essential aspects of the performance of the task. This was true to such an extent that phase checks could be used not for measurement alone, but also as a course of study. Study of the phase check itself did not invalidate later measures using the check, for, if the student were able to pass the check, he had adequate skill in the essential aspects of the task measured. Phase checks were developed for almost every task connected with the maintenance and adjustment of any type of gunnery equipment.

There were some defects in phase checks as criteria, however. Persistent attention had to be devoted to the motivation of the phase checkers in order that they would perform their work with care. Furthermore, the system of scoring itself was not entirely satisfactory (see chapter 8), especially for research purposes.

The biggest deficiency, of course, was that the checks did not measure the most essential aspect of the gunner's task.

As the gunnery training program developed, and especially as curriculums were based upon phase checks, the great majority of gunners became satisfactorily proficient in the areas measured by phase checks. There existed no requirement for differentiating precisely among gunners, all of whom had reached a high level of proficiency.

Achievement tests.—In certain areas of gunnery knowledge, proficiency could not be measured either by the application of phase check techniques or by use of some substitute criterion situation. This was particularly true of proficiency in theoretical knowledge and proficiency in emergency procedures. Proficiency in such areas was measured by printed achievement tests. Although a determination of whether or not proficiency on the tests might be expected to correlate with the efficiency of the gunner in combat was not made, it was assumed that under certain circumstances, at any rate, such proficiency would be important. Achievement examinations which were constructed in these areas were heavily loaded with pictorial items in an effort to reduce the factor of verbal facility to a minimum. These tests yielded scores which had reliabilities centering around 0.90 (see chapter 7).

Attempts to Obtain A Single Criterion Score

Ideally, for a criterion, one would desire a single score which would reflect in a dependable and sensitive fashion the proficiency of the individual gunner as compared with other gunners. Much of the research to be reported subsequently gave promise of improving gunnery training techniques to the point where pass-fail in gunnery school would have provided a reasonably adequate single criterion. Actually, however, the problem of arriving at a single criterion never fell within the realm of achievement in gunnery. Most effort was directed toward the development of discrete criteria which could be used to obtain estimates of the relative validity of various selection and training procedures.

CHAPTER SIX

The Selection of Gunners

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INTRODUCTION

Six Periods of Development

The problem of selection of gunners was manifold and constantly changing, requiring the use of many different hypotheses in the determination of the techniques and instruments to be used. Although changes in methodology and in the emphasis given specific problems proceeded along rather gradual lines of development, six specific periods in the development of selection procedures can be identified.

The first period was an exploratory one. In it, an attempt was made to define the variables making for success in gunnery school, and to try out various tests against existing criteria. The second period was characterized by the development of a single printed test based on valid items from various tests that had been tried out experimentally. The third period was characterized by the development of a more elaborate selection program comparable to that used in the selection of bombardiers, navigators, and pilots. In period four, investigations of appropriate methodology and devices for the measurement of attitudes, motivation, and adjustment were undertaken. In period five, the prediction of gun camera scores by aptitude tests was explored in experiments conducted in collaboration with the AAF School of Aviation Medicine. Period six was concerned with the selection of B–29 gunners and the use of stanines for this purpose, plus the determination of the effectiveness of available and of newly developed tests in predicting success in this type of training. The information accumulated in the first three periods had considerable transfer value to the B–29 selection program and facilitated the introduction of the selection program for these gunners.

The Interaction of Training and Selection

The six periods in the development of the selection program should be considered against a background of changing conditions of training. The impact of changes in gunnery equipment and methods on the determination of the skills which were important for prediction in a selection program was great, and frequent changes in equipment forced all possibility of a uniform selection program into the background. The speed with which equipment changed and the large number of gunners trained under a variety of conditions, combined with the absence of an adequate criterion of gunnery proficiency, made the application of systematic statistical studies for the improvement of a selection battery uneconomical.

An example of the influence of equipment changes on the determination of the factors which were important in predicting success in gunnery was the shift in importance attached to numerical aptitude as a requisite for gunnery training. In the early days of gunnery training, a method of sighting was used which required the gunner to make rapid arithmetical calculations. Later on, this type of proficiency became relatively unimportant, since compensating and computing sights performed all the calculations that were necessary. Increasing stress was placed on the smooth manipulation of equipment, concurrently with reduced demands upon the gunner for mastering of theory and factual information. This in turn meant increased emphasis on perceptual and manipulative aptitudes and reduced emphasis upon intellectual qualities.

The need for gunners was not determined solely by replacement requirements but also by requirements for gunners for new squadrons and groups. The flow of gunners was regulated by such factors as the capacity of available training installations and the number of men who were initially available for training as gunners. Consequently, up until the initiation of the B-29 training program, aptitude requirements could not be used to indicate which men should be assigned to gunnery schools.

Although in most cases the training program determined the nature of selection research, in some instances developments in selection techniques resulted in changes in training. For example, studies of attitudes and motivation of gunners, originally done for possible use in selection, resulted in valuable suggestions for the improvement of training. Again studies of the use of the B-29 pedestal sight manipulation test indicated that it could be used as a training device as well as a selection test.

The interaction of selection and training was nowhere better illustrated than in the B-29 gunnery program. Since the total

number of men needed for this type of training was less than the total number of gunners to be trained, it was possible to send men with most aptitude into B–29 gunnery, and to send men with less aptitude to B–17, B–24, and other types of training. And since men were being systematically selected for B–29 training, it was possible to pitch the B–29 training program at a higher level than was possible for other gunnery programs.

The process of training provided a further means of selecting gunners by the elimination of those men who failed to meet minimum requirements for proficiency in training. Thus selection tests were supplemented by a practical, job-sample test of the gunner's ability to perform in a situation that was a step closer to his combat job. This chapter will conclude with a discussion of the elimination policies followed in the AAF Training Command gunnery schools.

EXPLORATORY STUDIES OF TESTS FOR THE SELECTION OF GUNNERS

In September 1942, when the three Psychological Research Detachments at Tyndall, Harlingen, and Las Vegas were activated, their mission included two areas of investigation: the selection of graduate gunners to be trained as low-altitude bombardiers and the construction of aptitude tests for use in the selection of students to be given gunnery training. The selection program for low-altitude bombardiers soon became a matter of routine administration, and the activities of the detachments were centered around the task of developing a selection test battery for flexible gunnery.[1] The testing battery to be developed for the selection of flexible gunnery students would eventually be used by the AAF Technical Training Command. The policies of that command required that the battery be suitable for mass administration within a time limit of approximately 2 hours.

Description of Characteristics to be Measured[2]

The existing gunnery training program largely shaped the early selection program, for the job description upon which the first choice of tests was made included for the most part the factors associated with success in gunnery school. Other factors assumed to be associated with success in combat were given little weight.

[1] This work was done under the direction of Maj. C. W. Brown and Maj. Roger W. Russell at Las Vegas, Capt. Glen Finch and Capt. John T. Dailey at Harlingen, and Maj. Nicholas Hobbs and Maj. Glen L. Heathers at Tyndall.

[2] See chapter 5 for a more thorough discussion of the aptitudes considered relevant to gunnery.

Description of the gunner's job in terms of relevant behavioral characteristics were based upon talks with school officials, on interviews with successful and unsuccessful gunnery students, on examination of instructional materials, on observations made by psychologists going through the regular course of training, and on study of elimination policies.

At the time of this initial job description the elimination policies in force resulted in eliminating approximately 5 percent of the students in each class. The reasons for elimination at this time were as follows: (a) physical-medical, (b) military discipline, (c) fear of flying, (d) information proficiency, (e) manual proficiency, and (f) firing proficiency. Attention was directed primarily toward the last three of these reasons in the formulation of initial efforts to predict failure in gunnery training. Using these reasons for elimination as a guide, tests which purported to measure those abilities and aptitudes likely to be associated with success in training were selected, and new tests designed for gunnery selection were constructed.

Tryout of an Exporatory Battery

The abilities and aptitudes which seemed to have promise of being related to successful performance included the following: learning, mathematical ability, verbal facility, visual perceptual skills, mechanical comprehension, motor coordination, interests related to the job, and requisite personality traits. It should be noted that this description of factors pertinent to the gunner's duties was based on the course of instruction followed in the fall of 1942. The gunnery course was subsequently modified many times. The traits remained important but their relative significance changed.

The battery of tests used in the selection of low-altitude bombardiers, which is listed in Table 6.1 along with pertinent information concerning the tests, provided one exploratory battery for the selection of flexible gunners. Tests 1 through 7 were printed tests, and numbers 8 through 10 were apparatus tests. This battery was administered to all gunnery students as part of their regular school program. Having put into effect an initial battery which, it was anticipated, would yield data on a variety of aptitudes, work was begun on the planning of specifically designed new tests, and also on investigations of the criterion.

In the absence of a criterion of combat proficiency, the decision was made to use success in gunnery school as the best substitute criterion. Investigation of criterion measures in use at the gunnery schools led to the conclusion that the best measures available

in the schools were: (a) air-to-air firing scores, (b) ground range firing scores, (c) academic grades, and (d) graduation-elimina-

TABLE 6.1.—*Initial exploratory battery of aviation cadet classification tests for predicting gunnery proficiency*
(September-November 1942)

	Test weight [1]	Area weight	Scoring formula [2]
Tests of mathematical knowledge and reasoning:[3]		20	
1. Numerical operations — CI702B	5		(R-3W)/4
2. Mathematics — CI705A	10		R-W/4
3. Numerical approximations — CI706A	5		2R-W/2
Tests of alertness and observation		20	
4. Spatial orientation — CP501B	10		2R-2W/5
5. Speed of identification — CP610A	10		R-W
Tests of technical information and interest		20	
6. Mechanical principles — CI903A	10		R-W-20
7. Technical vocabulary — CE505Cr	10		2R-W/2
Tests of psychomotor abilities		40	
8. SAM visual coincidence reaction time — CP613A	15		60 trials
9. SAM discrimination reaction time — CP611D	15		60 trials
10. SAM two-hand coordination — CM101A	10		8 trials
Total	100	100	

[1] These weights, which were initially assigned for selection of D-8 Bombardiers, were used in arriving at a composite score on the 10 tests. The weights indicated were applied after correction for their respective standard deviations.

[2] Scoring formula after correcting for sigma differences.

[3] See Aviation Psychology Program Report No's. 4 and 5 for reliability figures.

tion. The performance required of a gunner on air-firing missions superficially appeared to approximate more closely the performance required in combat than the other measures. At Tyndall and Harlingen, however, the reliability of air firing scores approached zero. At Las Vegas the coefficients of reliability for air gunnery scores for classes 42-39 through 42-44 ranged between .32 and .44. By combining air-to-air firing scores with caliber .30 ground-to-ground firing scores, the range of reliabilities for these classes at Las Vegas was raised to a level of 0.50 to 0.69.

The preliminary battery of tests described above was administered to more than 2000 gunnery students at the 3 schools in September and October of 1943.[3] Data on the Army General Classi-

TABLE 6.2.—*Intercorrelations among various criteria used (October 1942)*[1]

School class criteria	Tyndall 42-42 (N=161)	Tyndall 42-43 (N=132)	Harlingen 42-41 (N=156)	Harlingen 42-42 (N=75)	Las Vegas 42-41 (N=227)	Las Vegas 42-41 (N=202)
Academic grades vs. air-to-air scores	0.05	−0.17 *	0.14	0.01	0.05	0.07
Academic grades vs.[2] ground range scores					.15 *	.21 **
Ground range scores vs.[2] air-to-air scores					.22 **	.37 **

[1] The number of times in 100 that a coefficient as large as each one obtained would be expected to arise by chance is indicated by the following system: No asterisk: more than 5 times in 100; *: between 1 and 5 times in 100; **: l[illegible]s than 1 time in 100.

[2] Ground range scores were available for Las Vegas data only.

[3] Intercorrelations of these tests, based on scores of 953 students in the 3 schools are presented in Table 1, Appendix B.

fication Test (AGCT) and Army Mechanical Aptitude Test (MA) were obtained from the Soldier's Qualification Cards (form 20's). Data on each of the four criteria listed above were secured from school records. Validity coefficients were computed for each class separately.

The intercorrelations among the criteria are shown in table 6.2. The fact that these correlations were low was interpreted to imply that each criterion measure should be treated separately in the statistical analysis. It was noted, however, that some promise of a relationship between ground range scores and both air-to-air firing and academic grades appeared. A low correlation between air-to-air firing and academic grades was found in all three schools.

In the prediction of air-to-air firing scores, it was found, as shown in table 6.3, that most of the validity coefficients were low and that considerable variation in the values appeared. Certain tests appeared to have possibilities, including Mechanical Principles, CI903A, Two-Hand Coordination, CM101A, Visual Coincidence Reaction Time, CP613A, and the Army Mechanical Aptitude Test (MA). The composite score on all 10 aviation cadet tests also showed promise. Speed of Identification, CP610A, and Spatial Orientation, CP501B and CP503B, yielded fairly high coefficients in some classes. It was noted, however, that among the tests enumerated above, only Mechanical Aptitude yielded coefficients which were sufficiently homogeneous statistically to permit combining the groups for determination of a correlation for the entire population. The primary implication of these results was that further work on the standardization of air-to-air firing and an increase in the reliability of criterion scores might permit prediction of proficiency in this area by the tests used, with some degree of consistency.

Usable data on ground range proficiency were limited to classes 42–40 and 42–41 at Las Vegas. The ground range score was a composite value obtained by combining scores earned on Skeet, Moving Base, Moving Target, the .22 Caliber Range, and the B. B. Range. For these data, as reported in table 6.4, the apparatus tests—Visual Coincidence Reaction Time, CP613A, Two-Hand Coordination, CM101A, and Speed of Reaction, CP611D—appeared most promising. Coefficients of 0.23 and 0.25 were obtained for composite scores on the 10 aviation cadet tests. Several of the printed tests appeared to have some possible value for predicting ground range scores.

The validity coefficients against academic grades, presented in table 6.5, were noticeably higher than those found for the other

TABLE 6.3.—*Correlations between air firing scores and 12 gunnery selection tests (October-November 1942)*[1]

Class	Mech. prin. CI903A	Numer. oper. CI702B	Speed ident. CP610A	Math. CI708A	Numer. approx. CI706A	Tech. voc. CE505C	Spat. O. CP501B CP503B	Speed react. CP611D	2-Hand coord. CM101A	Vis. coIa. CP61?A	Composite	AGCT	MA	N
Tyndall:														
42-39	0.05	—.08	0.01	—0.05	—0.01	0.15	0.08	0.01	—0.04	0.04	0.03			164
40	.16	.01	.04	.02	.00	.02	.07	.12	.12	.04	.14	0.18 *	0.18	116
41	—.02	—.03	.15	—.02	—.02	—.08	.09	.13	.09	.00	.05	.06		198
42	—.16 *	.08	.06	.00	.04	—.01	.00	.07	.21 **	.12	.12	.01	.10	161
43	.12	—.08	.10	.06	—.09	—.01	.02	.08	.07	.05	.04	—.06	.03	132
44	.14	—.03	—.09	.06	.03	.00	—.01	—.07	—.03	.17 *	.03	—.04	.13	171
Harlingen:														
42-40	.16 *	—.06	.02	.01	—.02	.12	—.03	.07	.13	.10	.10			184
41	.24 **	—.07	.20 *	—.03	.01	.11	.22 **	.13	.19 *	.13	.23 **	.04	.11	154
42	.14	—.05	—.03	.13	—.05	.04	.18	.07	.13	.07	.14	.19	.23 *	75
43	—.17	—.06	—.05	—.02	.04	—.09	—.14	.00	.05	.34 **	—.02	—.06	.02	88
44	.23 *	.01	.06	.05	.04	.11	.03	—.04	.08	.07	.16	.05	.31 **	76
45	.11	—.14	.07	.09	.04	.23	.16	.11	.16	.11	.22	.10	.25 *	58
Las Vegas:														
42-39	.17	.08	.26	.12	.00		.20	.12	.19	.01				
40	.21 **	—.01	.19 **	.02	.05	.07	.11	.10	.25 **	.11	.19 **	.01		227
41	.23 **	.06	.17 *	.08	.02	.13	.24 **	.19 **	.23 **	.23 **	.31 **	.10	.14 *	202
42	.28 **		.23 **			.22 **	.20 *					.09	.20 *	174
Total r[2]		.02		.03	.01	.05 *		.09 **				.04	.12 **	
Median	.15	—.03	.06	.02	.01	.07	.08	.07	.13	.10	.11	.05	.14	

[1] The number of times in 100 that a coefficient as large as each one obtained would be expected to arise by chance is indicated by the following system: No asterisk: more than 5 times in 100; one asterisk (*): between 1 and 5 times in 100; two asterisks (**): less than 1 time in 100.

[2] Total r's were computed on the basis of all cases combined. Correlations on Las Vegas class 42-39 were not included in total r's. For tests in which the variation in obtained validity coefficients was so large as to be expected to arise by chance less than 5 times in 100, no total r was computed.

TABLE 6.4.—*Correlations between ground range scores and 12 gunnery selection tests (October-November 1942)*[1]

Class	Mech. prin. CI903	Numer. oper. CI702B	Speed ident. CP610A	Math. CI708A	Numer. approx. CI706A	Tech. voc. CE505C	Spat. O. CP501B CP503B	Speed react. CP611D	2-Hand coord. CM101A	Vis. coin. CP613A	Composite	AGCT	MA	N
Las Vegas:														
42-40	0.12	0.05	0.11	0.01	−0.04	0.02	0.17	0.21 **	0.25 **	0.23 **	0.23 **	0.02	—	227
42-41	.15 *	.12	.16 *	.06	.01	.00	.10	.18 **	.20 **	.31 **	.25 **	.06	0.17	202

[1] The number of times in 100 that a coefficient as large as each one obtained would be expected to arise by chance is indicated by the following system: No asterisk: more than 5 times in 100; *: between 1 and 5 times in 100; **: less than 1 time in 100.

TABLE 6.5.—*Correlations between academic grades and 12 gunnery selection tests (October-November 1942)*[1]

Class	Mech. prin. CI903A	Numer. oper. CI702B	Speed ident. CP610A	Math. CI708A	Numer. approx. CI706A	Tech. voc. CE50	Spat. O. CP501B CP503B	Speed react. CP611D	2-Hand coord. CM101A	Vis. coin. CP613A	Composite	ACCT	MA	N
Tyndall:														
42–39	0.30 **	0.30 **	0.14	0.42 **	0.36 **	0.53 *	0.22 **	0.41 **	0.17 *	0.22 **	0.53 **			164
40	.23 **	.36 **	.17 *	.54 **	.40 **	[illegible]	.23 **	.07	.16	.01	.44 **	0.41 **	0.28 **	116
41	.32 **	.34 **	.25 **	.51 **	.38 **	.52 *	.28 **	.45 **	.21 **	.06	.54 **	.55 **		196
42	.48 **	.42 **	.22 **	.54 **	.42 **	.55 **	.34 **	.49 **	.33 **	.24 **	.63 **	.52 **	.48 **	161
43	.04	.10	.09	.31 **	.21 *	.27 *	.07	.20 *	.09	.11	.24 **	.21 *	.04	132
44	.20 **	.28 **	.25 **	.37 **	.34 **	.43 *	.23 **	.17 *	.10	.02	.39 **	.41 **	.43 **	171
Harlingen:														
42–40	.29 **	.37 **	.13 **	.54 **	.40 **	[illegible]	.25 **	.48 **	.13	.22 **	.61 **			184
41	.18 *	.22 **	.16 *	.31 **	.03	.46 **	.15	.34 **	.20 *	.12	.44 **	.36 **	.34 **	156
42	−.12	.37 **	.07	.23 *	.24 *	.16	.14	.02	−.15	−.04	.13	.19	.14	75
43	.06	.28 **	.05	.46 **	.31 **	.42 **	.15	.40 **	.30 **	.12	.46 **	.40 **	.46 **	68
44	.18	.47 **	.11	.39 **	.29 **	.33 **	.17	.25 *	.05	.22 *	.41 **	.36 **	.25 *	76
45	.27 *	.18	.22	.46 **	.28 *	.61 **	.20	.16	.06	.17	.48 **	.40 **	.44 **	58
Las Vegas:														
42–40	−.01	.14 *	.18 **	[illegible]	.24 **	.14 *	.18 **	.10	.04	.11	.22 **	.16 *		227
41	.12	.39 **	.35 **	.24 **	.29 **	.25 **	.21 **	.38 **	.14 *	.28 **	.48 **	.34 **	.29 *	202
Total r[2]			.17 **				.20 **							
Median r	.19	.32	.18	.40	.30	.44	.20	.30	.14	.12	.45	.38	.32	

[1] The number of times in 100 that a coefficient as large as each one obtained would be expected to arise by chance is indicated by the following system: No asterisk: more than 5 times in 100; one asterisk (*): between 1 and 5 times in 100; two asterisks (**): less than 1 time in 100.
[2] Total r's were computed on the basis of all classes combined. For tests in which the variation in obtained validity coefficients was so large as to be expected to arise by chance less than 5 times in 100, no total r was computed.

criteria. Among the tests which had relatively high validities were Technical Vocabulary, CE505C, Mathematics, CI708A, Numerical Operations, CI702B, AGCT, and MA. The composite score on the aviation cadet tests was also high, with a median coefficient of 0.45 for 14 classes. The values for AGCT and MA, which had median coefficients of 0.38 and 0.32 respectively, were given special consideration, because scores on these tests were already available for most gunners prior to their assignment. Examination of the data presented in table 6.5 revealed considerable variation in the size of the coefficients, an observation which was borne out by analysis of their statistical homogeneity. Of all the tests, only two showed an amount of variation small enough to be expected to arise by chance as often as 5 times in 100. Although the reason for this variation cannot definitely be assigned, observations of gunnery schools at this time suggested that variations in testing and training conditions for the academic criterion probably provided the chief source of variation.

Biserial correlation coefficients of the various tests with graduation-elimination are presented in table 6.6. Interpretation of these results is complicated by the fact that in computing the coefficients on the Harlingen data, the standard deviation on the test was determined for graduates only rather than for the total group. This means that the reported biserials are probably overestimates to some extent. To overcome this difficulty, coefficients were determined for 825 students in 3 classes at Las Vegas; but

TABLE 6.6.—*Biserial correlations for 12 proposed gunnery selection tests and composite score on 10 cadet classification tests against graduation—elimination from gunnery school (October-November 1942)*

Test	Code	Harlingen[1]				Las Vegas[2]
		M_g	M_e	SD_g	r_{bis}	r_{bis}
Mech. prin.	CI903A	5.89	3.73	6.95	0.16	0.24
Numer. oper.	CI702B	16.25	18.30	6.13	—.17	.34
Speed ident.	CP810A	25.73	16.93	7.50	.60	.42
Math.	CI708A	11.24	7.05	5.71	.38	.32
Numer. approx.	CI706A	7.87	4.10	5.30	.36	.22
Tech. voc.	CE505C	21.03	10.25	13.59	.41	.20
Spatial orient.	CP501B, 503B	47.80	42.12	12.52	.24	.17
Speed react.	CP611D	95.55	82.78	20.18	.32	
Two-Hand coord.	CM101A	52.97	51.20	10.61	.09	
Visual coincidence	CP613A	51.01	48.50	8.32	.15	
Composite (10 tests)		328.76	281.47	54.84	.44	.53
AGCT[4]		111.79	101.68	12.96	.42	.35
MA[4]		105.41	98.15	15.49	.25	.32

[1] For the Harlingen data, N_g=621 and B_g=91 percent. In computing the biseral r's, the SD of the graduating group was used as an estimate of the SD of the total group. Classes 42-40 through 42-45 were used.

[2] For the Las Vegas data, N_t=825 and P_g is unknown. Classes 42-44 through 42-46 were used.

[3] For N=825 and $_q$=91, a biserial r as large as 0.14 would be expected to occur by chance less than 5 times in 100; a biserial r as large as 0.18 would be expected to occur by chance less than 1 time in 100.

[4] N is somewhat smaller because of missing data.

for this group the value of p_x is unknown. It appeared from the data obtained that Speed of Identification, CP610A, Mathematics, CI708A, Technical Vocabulary, CE505C, and AGCT showed relatively high correlations (generally above 0.30) for both populations. The composite score on the 10 tests showed a correlation of 0.44 in the Harlingen data and 0.53 in the Las Vegas data, which was considered promising. In an effort to ascertain the maximum efficiency to be expected in predicting academic grades, a multiple correlation analysis of data for one class in each of the three schools was carried out. For each school, the last class on which complete test data were available was used. The particular tests upon which the multiple correlations were based were Mechanical Principles, CI903A, Speed of Identification, CP601A, Mathematics, CI708A, Technical Vocabulary, CE505C, AGCT, and MA. For comparison, the multiple correlation of AGCT and MA with academic grades was computed. The results are presented in table 6.7. The values found indicated that the addition of certain of the aviation cadet tests consistently resulted in increased prediction. However, it was noted that the gains in predictive efficiency over the use of AGCT and MA only were small enough to be expected to arise by chance more than 5 times in 100.

TABLE 6.7.—*The prediction of academic grades by two test batteries in each of three gunnery schools (October-November 1942)*

Test battery	Tyndall class 42–44 (N=171)	Harlingen class 42–45 (N=58)	Las Vegas class 42–41 (N=202)
AGCT, MA, Mech. Princ., CI903A Speed of Ident., CP610A, Math. CI708A, and Tech. Vocab., CE505C	0.55	0.66	0.44
AGCT and MA	.49	.49	.36

A multiple correlation analysis of the prediction of air-to-air firing scores was made on data available for 174 students in Class 42–42, Las Vegas. This class was chosen because the reliability of air-to-air firing scores had been found to be 0.41, the highest value obtained. For this class, the multiple correlation of Mechanical Principles, CI903A, Speed of Identification, CP610A, Technical Vocabulary, CE505C, Spatial Orientation, CP501B, AGCT, and MA with air-to-air firing scores was computed. Except that Spatial Orientation, CP501B, had been substituted for Mathematics, CI708A, the battery was the same as that used for predicting academic scores. It was found that the multiple correlation for the six tests was 0.38; while the comparable figure for AGCT and MA only was 0.20. The values obtained were such as

to make further study of the problem of predicting air-to-air firing appear desirable.

THE DEVELOPMENT OF THE APTITUDE TEST FOR AERIAL GUNNERS, AC30A

Tests Used as a Basis for AC30A

The initial exploratory studies indicated that Army General Classification Test scores were reasonably dependable as predictors of academic success but that they were not so effective with respect to air-to-air firing. Further work was accordingly oriented in terms of developing a new test which would supplement AGCT in the prediction of gunnery proficiency.

In developing the new gunnery test, consideration was given to the results already reported and to various less systematic studies of a variety of tests. In all, 62 different tests were tried out, including a number of tests developed by the gunnery detachments. Table 2, appendix B, reports validity coefficients for 38 of these tests upon which information is available at the time of this writing. These results, interpreted in the light of experience with the various tests in gunnery schools, were used in formulating hypotheses regarding the most suitable tests for use in gunnery selection. It was also decided that a printed test would be best adapted to the testing facilities available at the stations where gunners were selected. On the basis of available evidence, nine tests were chosen as primary sources for items for the new test, which was called the Aptitude Test for Aerial Gunners and was given the code of AC30A. Validity coefficients for these source tests, reliabilities where available, and the part of AC30A derived from each source are presented in table 3, appendix B. The validity coefficients were based on various populations in the three schools. Table 4, appendix B, presents a summary of all intercorrelations which were available for use in planning the new test. The populations on which these intercorrelations were based are unknown.

Validation of Aptitude Test for Aerial Gunners, AC30A

Table 6.8 identifies the various parts of AC30A and specifies the amount of time allowed for each part. Since the Plane Name Memory sub-test and the Gunnery Learning sub-test involved alternating periods of study and testing, the time alloted to each of these activities is also specified.

During July and August of 1943, AC30A was administered to approximately one thousand basic gunnery students in Classes 44-35 through 43-38 at Buckingham. The intercorrelations among the nine parts, total scores, and three criteria, together

with validity coefficients for each part and for total score against each criterion are shown in table 6.9.[4] Each of the parts had a validity coefficient with score on the Gunnery Final Examination (Form GFC) which was significant at the 0.01 level. The validity coefficients against ground range scores and air-to-air firing scores were relatively low, none of these being higher than 0.11. Since AGCT scores were not obtained for this population, the extent to

TABLE 6.8.—*Format of the Aptitude Test for Aerial Gunners, AC30A*[1]

Part	Name	Activity	Time
			Minutes
I	Technical vocabulary	Test	15
II	Plane name memory section A (front silhouette)	Study	4
		Test	4
	Section B (side silhouette)	Study	4
		Test	4
III	Gunnery learning section A (oil buffer unit)	Study	2
		Test	2
	Section B (aerial cannon)	Study	5
		Test	4
	Section C (Martin turret)	Study	2
		Test	2
IV	Mechanical principles	Test	15
V	Gunnery mathematics section A	Test	5
	Section B	Test	10
VI	Speed of identification	Test	4
	Total		82

[1] The scoring formula for this test (AC30A) is the number of answers correctly marked minus ¼ the number of answers marked incorrectly. (The maximum possible score is 211).

which AC30A fulfilled the function of supplementing AGCT was not answered by this study. Moreover, the low intercorrelations among the criterion scores were considered to indicate a need for further efforts to obtain better criteria of gunner proficiency. In the absence of specific reliability estimates for the criteria, this interpretation of the results was necessarily tentative.

During the early part of 1944, a systematic study of the prediction of gunnery proficiency was undertaken. One class (44-4, Buckingham) was chosen for detailed study. In addition to AC30A, the Aviation Cadet Qualifying Examination, AC12J, three motion picture tests, the Plane Formation Test, CP805B, and the Angular Judgment test were administered. A Biographical Data Blank designed for gunners and the Opinion Poll for gunners were administered also. As criteria, Gunnery Final Examination (Form GFC), Skeet Range, Moving Range, Shotgun Turret Range, Jeep Range, and Jam-Handy (E-14) Trainer scores were obtained.[5]

[4] Statistical computations were done by the Psychological Section, Office of the Surgeon, Headquarters, AAF Training Command.

[5] This study was planned and supervised by Capt. Mason Haire and Capt. Theodore R. Vallance. Description of the various ranges and of the Jam-Handy (E-14) Trainer are given in chapter 9.

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TABLE 6.9.—*Intercorrelations of parts of AC30A and validity coefficients with each of three gunnery criteria (N=1000; classes 43-35 through 43-38, Buckingham, September 1943)*[1]

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. AC30A Part I Gunnery int. and voc.	----------	0.35	0.24	0.26	0.33	0.46	0.41	0.42	0.27	0.64	0.09 **	0.44 *	0.10 *
2. AC30A Part II plane memory	0.35	----------	.38	.42	.44	.30	.37	.39	.40	.75	.02	.20 **	.03
3. AC30A Part III Gunnery learning A.	.24	.38	----------	.45	.34	.22	.28	.22	.31	.51	.05	.23 **	.09 **
4. AC30A Part III Gunnery learning B.	.26	.42	.45	----------	.36	.24	.40	.31	.32	.59	.05	.30 **	.02
5. AC30A Part III Gunnery learning C.	.33	.44	.34	.36	----------	.31	.39	.41	.37	.62	.04	.27 *	.02
6. AC30A Part IV mech. prin.	.46	.30	.22	.24	.31	----------	.38	.40	.30	.63	.11 **	.39 *	.06
7. AC30A Part V mathematics A.	.41	.37	.28	.40	.39	.38	----------	.58	.32	.64	.03	.32 **	—.01
8. AC30A Part V mathematics B.	.42	.39	.22	.31	.41	.40	.58	----------	.37	.65	.02	.34 *	.02
9. AC30A Part VI speed of ident.	.27	.40	.31	.32	.37	.30	.32	.37	----------	.71	.03	.29 *	.06 *
10. AC30A Total	.64	.75	.51	.59	.62	.63	.64	.65	.71	----------	.07 *	.49 *	.07 *
11. Composite Range Score	.09 **	.02	.05	.05	.04	.11 **	.03	.02	.03	.07 *	----------	.15 **	.05
12. Gunnery Final (GFC)	.44 **	.30 **	.23 **	.30 **	.27 **	.39 **	.32 **	.34 **	.29 **	.49 **	.15 **	----------	.17 **
13. Air-to-air Firing Scores	.10 **	.03	.09 **	.02	.02	.05	—.01	.02	.06 *	.07 *	.05	.17 **	----------
Mean	17.75	18.98	8.53	15.07	4.07	18.68	10.20	5.30	24.43	122.97	579.34	116.99	13.17
SD	4.53	7.39	1.67	3.27	2.49	5.05	2.76	2.34	7.36	24.50	87.36	11.86	4.98

[1] All intercorrelations of the parts of AC30A are sufficiently large to be expected to arise by chance less than 1 time in 100. For the validity coefficients, the number of times in 100 that a coefficient as large as each one obtained would be expected to arise by chance is indicated in the following system: No asterisk: more than 5 times in 100; one asterisk (*): between 1 and 5 times in 100; two asterisks (**): less than 1 time in 100.

TABLE 6.10.—*Intercorrelations among criterion scores used for validation of the experimental test battery (class 44–4, Buckingham; N varies from 246 to 277; January 1944)*

Criterion	Intercorrelations						M	SD
	1	2	3	4	5	6		
1. Gunnery final (Form GFC).	—	0.11	0.11	0.06	0.06	0.03	126.2	8.4
2. Skeet	0.11	—	.53	.16	0.06	.08	61.8	10.8
3. Moving base	.11	.53	—	.16	.11	−.04	53.6	9.2
4. Shotgun turret	.06	.16	.16	—	.16	.07	64.5	8.8
5. Jeep range	.06	.06	.11	.16	—	.02	23.8	5.1
6. Jam-Handy (E–14)	.03	.08	−.04	.07	.02	—	4.2	1.3

Table 6.10 presents the intercorrelations among the six criteria used in this study. Except for a rather high correlation between Skeet Range scores and Moving Base Range scores, and for some tendency for the three shotgun ranges (Skeet, Moving Base, and Shotgun Turret) to be correlated with each other, the results gave no reason to believe that the various criteria were related to each other. The reliability of the separate criteria for this group is unknown. Intercorrelations among the 11 test scores are shown in table 5, appendix B.

TABLE 6.11.—*Validity coefficients for experimental test battery with each of seven criteria of gunnery proficiency (class 44–4, Buckingham; N varies from 166 to 277; January 1944)*[1]

Test	Criterion						
	GFC	Skeet	Moving base	Shotgun turret	Jeep range	Comp. range score	Jam-Handy E–14
AGCT	0.30	−0.03	−0.05	0.02	0.01	0.00	0.05
MA	.35	.11	[illegible]	.09	.02	.12	−.06
AC12J	.47	.16	.05	.10	.07	.19	−.06
AC30A	.41	.15	.15	.11	.01	.15	.08
Plane formation CP805C	.15	.05	.07	.06	.06	.13	.07
Angular judgment	.24	.09	.04	.15	.13	.25	−.01
Est. of veloc. CP205–I	−.06	−.09	−.05	−.07	.05	−.02	.01
Ident. of veloc. CP205–II	.03	.21	.07	.08	.16	.30	.10
Est. of rel. veloc. CP205–III	−.06	.05	−.01	.02	.07	.09	−.10
Biographical data	.14	.01	.04	−.03	−.03	−.03	−.09
Opinion poll	−.03	.04	.08	−.01	−.04	.02	.10

[1] Positive correlations indicate that "goodness" of performance on the test is associated with "goodness" of performance on the criterion.

For N=166, a coefficient as large as 0.15 would be expected to arise by chance 5 times in 100; and a coefficient as large as 0.20 is likely to arise by chance 1 time in 100.

Validity coefficients for each of the tests against each criterion are presented in table 6.11. It was noted that both AC30A and AC12J yielded somewhat higher validity coefficients than AGCT or MA, not only for the Gunnery Final Examination but for most of the other criteria.[6] For this sample, the values for MA were

[6] The multiple correlation of AGCT and MA with GFC was 0.35; the zero-order coefficient of AC30A with GFC was 0.41.

somewhat higher than those for AGCT. The results also suggested that the Angular Judgment Test and the Identification of Velocity Test, CP205-II, had some promise as predictors of combined scores on the four ground range criteria. None of the tests included showed any appreciable degree of correlation with the Jam-Handy (E-14) scores. On the whole, this study indicated that the tests included were not particularly effective in predicting any of the criteria except Gunnery Final Examination scores.

THE DEVELOPMENT OF GUNNERY STANINES

Additional Statistical Studies

In the fall of 1943, a study of the prediction of gunnery proficiency was carried out, the results of which were later used in the determination of gunnery stanines. The study was organized around aviation cadet selection and classification tests and existing stanine scores. Criteria used were Gunnery Final Examination (Form GFC) scores, Jam-Handy (E-14) Trainer scores, ground range scores, and air-to-air firing scores. The population used included 194 students in class 43-45, and 173 students in class 43-48, at Buckingham, all of whom had previously taken the aviation cadet selection and classification battery. Statistical analyses were carried out for each class separately.[7]

Table 6.12 presents only those validity coefficients for age, stanines, and strength of interest in becoming a bombardier, navigator, or a pilot which were sufficiently high to be expected by chance less than 5 times in 100. All validity coefficients, together with distribution constants, are presented in Tables 6 and 7 in

TABLE 6.12.—*Validity coefficients of age, strength of interest, and aviation cadet stanines with four gunnery criteria (classes 43-45, N=194; and 43-48, N=173; Buckingham, November-December 1943)*[1]

	Gunnery final (GFC)		Jam-Handy scores		Percent hits ground ranges		Percent hits air firing	
	Class		Class		Class		Class	
	43-45	43-48	43-45	43-48	43-45	43-48	43-45	43-48
Age					0.17			0.17
Bombardier stanine	0.21 *	0.47 *						.15
Navigator stanine	.25 *	.25 *		−0.15				
Pilot stanine	.35 *	.53 *						.20 *
Augmented pilot stanine	.34 *	.52 *						.18
Strength of interest bombardier		−.20 *						

[1] This table includes only correlations sufficiently large to be expected to occur by chance less than 5 times in 100. An asterisk to the right of a coefficient indicates that it is sufficiently large to be expected to occur by chance less than 1 time in 100. Further data on validity coefficients for this study are presented in tables 6 and 7, appendix B.

[7] Maj. John V. McQuitty was responsible for these studies.

appendix B. It was found that stanine scores for bombardier, navigator, and pilot had validity coefficients for predicting Gunnery Final Examination (GFC) scores so large as to be expected by chance less than 1 time in 100. The pilot stanine yielded somewhat higher validities than the other stanines for this criterion. Of the other criteria, only air-to-air firing scores in class 43-48 yielded validities which were significant at the 5 percent level. Here again the pilot stanine was slightly higher.

In table 6.13, all validity coefficients for the various tests which were sufficiently high to be expected by chance less than 5 times in 100 are presented. Validity coefficients for all tests used, together with distribution constants, are presented in tables 6 and 7 in appendix B. It is noted that a number of tests showed moderately high coefficients with Gunnery Final Examination scores. Results on the prediction of Jam-Handy (E-14) Trainer scores were low and inconsistent; while for ground range scores virtually none of the tests showed promising correlations. For air-to-air firing, none of the validities for class 43-45 reached the level required for inclusion in the summary tables, but a number of coefficients significant at this level were found for class 43-48.

Among the various tests, Technical Vocabulary Pilot, CE505C, Technical Vocabulary Bombardier, CE505C, Spatial Orientation II, CP503B, and Reading Comprehension, CI614G, seemed most promising in so far as their validity coefficients against Gunnery Final Examination (GFC) scores and against air-to-air firing scores were concerned.

The Gunnery Stanines

The consolidation of the AAF Technical Training Command and the AAF Flying Training Command made possible the introduction of more elaborate procedures for the classification of gunners. A large proportion of candidates for gunnery training were routinely tested by the Psychological Research Units and by the Medical and Psychological Examining Units. These units had experienced personnel and were equipped to administer both printed and psychomotor tests, thus making possible more flexibility in testing.

Coincident with the validation of the aviation cadet selection and classification tests with gunnery criteria, there were similar investigations of the validity of these tests with the criteria of success in technical training schools. In addition, personnel were sent to the European Theater of Operations and to other theaters to investigate the efficacy of the existing selection procedures as well as to obtain a better description of the various air-crew jobs. These data, together with those reported above, were used to ar-

rive at stanines for the various combat crew members. Since the majority of enlisted aircrewmen were given gunnery training as well as technical training, the classification program had to take into consideration the problems involved in the prediction of success in both types of training and duty. In September 1944, stanines were prepared for Radio Operator-Gunner, Mechanic Armorer-Gunner, and Aerial Gunner.

The factors making possible more refined and extensive classification procedures for the selection of gunners, however, were in no way related to those determining the need for gunners. The

TABLE 6.13.—*Validity coefficients of cadet classification tests with four gunnery criteria (classes 43–45, N=194, and 43–48, N=173, Buckingham, November-December 1943)*[1]

Test	Code	Gunnery final (GFC)		Jam-Handy scores		Percent hits Ground ranges		Percent hits air-to-air	
		Class		Class		Class		Class	
		43–45	43–48	43–45	43–48	43–45	43–48	43–45	43–48
Tech. vocab. pilot	CE505C	0.45 *	0.31 *				0.16		0.25 *
Tech. vocab. nav.	CE505C	.26 *							.15
Tech vocab. bomb.	CE505C	.19 *	.22 *						.16
Mech. prin.	CI903A	.35 *	.46 *	0.14	−0.17				
Mech. info.	CI905A	.31 *	.36 *		−.15				.15
Reading comp.	CI614C	.28 *	.41 *	.15	−.23 *				.15
Speed of ident.	CP610A	.26 *	.24 *						
Spatial orien. I	CP501B		.30 *						.19
Spatial orien. II	CP503B	.32 *	.18						
Dial tab. read.	CP622-21A		.17						
Math. A	CI702B				−.16				
Math. B	CI706A, CI206B.	.17	.15						
Numer. oper. B							−.15		
Numer. oper. F		−.20 *							
Complex coord.	CM701A		.40 *		−.15				
Disc. react. time	CP611D		.27 *						
2-Hand coord.	CM101A		.37 *						
Aiming stress	CE211A		−.18						−.18

[1] This table included only correlations sufficiently large to be expected to occur by chance less than 5 times in 100. An asterisk to the right of a coefficient indicates that it is sufficiently large to be expected to occur by chance less than 1 time in 100. Further data on validity coefficients for this study are presented in Tables 6 and 7, Appendix B.

need for gunners exceeded the supply of candidates, making the application of a selection procedure superfluous, since all available men had to be trained and used. Classification continued and stanine scores were recorded in service records in case it became possible at sometime in the future to select men for gunnery training. However, up to the time when B–29 gunnery training expanded, late in 1944, the prospects for initiating a gunnery selection program were remote.

RESEARCH ON PERSONALITY FACTORS ASSOCIATED WITH SUCCESS IN GUNNERY TRAINING

Introduction.—In view of the situations of marked stress to which the gunner was likely to be exposed, and of the necessity that he be able to function under these circumstances, the importance of obtaining stable, well-adjusted individuals for this job was recognized as an important area for research in gunnery selection.

Considerable literature was available from both army and civilian sources describing previously tried approaches to problems of measuring personality. It was necessary to verify the hypotheses underlying their development in order to obtain evidence to support their use as selection devices in flexible gunnery. Administration to large numbers of men in the army also permitted refinement of the instruments, which, in most instances, had been originally validated on small homogeneous groups.

Studies of ex-combat gunners.—The first step in the investigation of personality variables which might have been associated with success in gunnery training was the exploration of the adjustment of returnee gunners from various theaters of operation. It was found in these studies, for example, that 24 percent of the men studied had experienced a degree of combat strain sufficient to interfere with their functioning as gunners, and that an additional 50 percent showed moderate signs of combat strain. It was also found that men who were better able to withstand combat strain were more likely to be men who (a) had had a satisfactory adjustment in early life, (b) possessed superior intelligence, and (c) were married. Age did not seem to be a factor in combat strain. It was concluded that men who would not be likely to show combat strain would be those individuals who were: psychologically secure in their group relationships, in their family relationships, and in their religious faith; who were independent; who had clearly defined purposes and goals; who were superior in ability; and who were of stable disposition.[8] This study reinforced the hypothesis that there was a need for the consideration of the problem of predicting combat adjustment, and, in addition, it presented some leads as to possible factors which might be measured by tests designed for use in a selection program.

Development of the test for emotional security of basic gunners.—As a first step in investigating personality variables which might have been associated with the combat effectiveness of gun-

[8] This study was conducted by Dr. Carl R. Rogers, assisted by Capt. Wilbur S. Gregory and Lt. Thomas P. Gallagher. Further information on this study is presented in Chapter 10.

ners, it was decided to investigate the possibilities of a projective technique, similar to Murray's Thematic Apperception Test.[*] The principles used in the development of the Thematic Apperception Test were used to guide the development of the Test for Emotional Security of Basic Gunners. It was believed that in reacting to pictures susceptible of varying interpretations, gunners might give responses indicative of instability and insecurity more freely than they would in a conventional attitude questionnaire.

The Test for Emotional Security of Basic Gunners consisted of 32 pictures, reproduced on slides. Each picture was projected on a screen, and the subjects were required to indicate their reactions to each of the pictures, in the first edition of the test, by writing free responses, and, in a later edition, by checking alternatives presented in a check list. All but five of the pictures included one or more individuals with whom the subject might identify himself, and many of them involved some war motif (e.g., soldiers diving for a slit trench, American prisoners on Bataan). On the check list, the alternatives presented were of the following nature: "A wounded straggler who cannot keep up with his buddies." "This soldier has just found the body of a friend," "An artilleryman relaxing during a lull in a battle," "This soldier realizes that every day will be like this until he is killed or the war is over" and "This man is fed up with war."

In a preliminary study of validity, the criterion was an anonymous questionnaire designed in accordance with the findings of Roger's study of the adjustment of ex-combat gunners (see chapter 10). This questionnaire was designed to measure such factors as degree of independence, clarity of purposes and goals, and security in social groups, in family relationships, and in religious faith. It contained 38 items, of which 18 were concerned with attitudes towards gunnery and twenty with security factors. Weights were assigned to responses on the basis of judgment of psychologists, with positive responses indicating security and negative responses indicating insecurity. The distribution of obtained scores on the questionnaire for 99 gunnery students yielded a mean score of 15.6 with a standard deviation of 7.2.

To obtain a preliminary estimate of the diagnostic value of the test in multiple-choice form, separate item tabulations were made for the 25 highest and 25 lowest scoring individuals on the questionnaire. Differences between the two groups with respect to responses to pictures did not prove to be great; about one-third of the pictures yielded some reliable differences between the

[*] This work was primarily the responsibility of Lt. Gerald R. Pascal, assisted by Lt. William K. Estes.

groups. Since about twice as many of the statements yielded differences significant at the 5 percent level as would be expected on the basis of chance alone, it was inferred that the multiple-choice picture test had some promise, but that extensive research would be needed to develop an effective instrument of this type. It was noted that, in general, the group judged as insecure on the basis of the questionnaire scores tended to select more frequently the responses involving anxiety or dread.

The Test for Emotional Security of basic gunners, with the results of this exploratory investigation, was forwarded to the AAF Redistribution Station at Atlantic City with the suggestion that the test might be more fruitfully studied using psychiatric and non-psychiatric cases among gunners returning from combat.

Studies of attitude scales.—The next step in the exploration of personality variables associated with efficient performance in gunnery was an investigation of attitudes.[10] It was first necessary to select the areas of attitudes to be investigated and to determine practical means of reliably measuring them. The areas of attitudes selected for study were attitudes toward the Army in general, towards flexible gunnery, and towards related activities. Also selected for study were more generalized attitudes which might possibly be symptomatic of basic personal adjustment. It was assumed that a preponderance of negative or hostile attitudes as revealed by a scale covering the above areas would indicate that the candidate for gunnery training was a poor risk. However, it was agreed that this information on attitudes must be interpreted within the general framework of the aptitudes of a particular individual as measured by other classification tests. The goal was the unification of the results of attitude measurements and of aptitude measurements into composite indexes.

The attitudes were studied by means of a multiple-choice type of questionnaire, called the Opinion Poll, to which the candidate responded by checking one of five alternative statements. Typical examples of the items used are: "A man would be a better gunner as a sergeant than as a corporal," "Married men should not be sent to flexible gunnery school," "A man who has always been a pacifist would not make a good flexible gunner," "Very religious men do not make good gunners," and "The chances are that when a flexible gunner does get hit, he'll get it in the head." Using a separate answer sheet, the candidate indicated the degree of his agreement or disagreement on the following five-point scale: Strongly agree, Agree, Undecided, Disagree, Strongly disagree.

[10] This work was primarily the responsibility of Lt. Gerald R. Pascal assisted by T/Sgt. Hyman Kaitz.

All items were not scaled in the same direction, and, in addition, statements were phrased in both negative and positive terms in order to minimize the set which often contributes to the "halo effect."

The scale as finally developed had 78 items. There was no time limit, but the scale took about 35 minutes to complete. The scoring formula made use of a weighted scale ranging from 1 to 5. The scoring key was based on the judgment of a group of psychologists concerning the significance of each item in terms of adjustment. The scale was found to have a satisfactory reliability ($r = .87$, $N = 210$, Kuder-Richardson Formula 21). The validity coefficients obtained in an exploratory investigation of this scale are presented in table 6.14 below.

TABLE 6.14.—*Validity coefficients of test of attitudes toward flexible gunnery against various criteria of success in the basic gunnery school, and against judgment of adjustment made by interviewers (Buckingham, January 1944)*

Class	N	Criteria	Validity coefficient
44-4	210	GFC	−0.03
44-4	210	Skeet	.04
44-4	210	Moving base	.08
44-4	210	Shot gun turret	−.01
44-4	210	Jeep	−.04
44-4	210	Jam-Handy	.10
44-4	210	Interviews [1]	.43

[1] Reliability coefficient of interviews is 0.79, computed by Kuder-Richardson Formula No. 21.

It can be seen from the data in table 6.14 that the attitudes as measured by this scale did not correlate significantly with any of the measures of performance. However, a correlation of 0.43 was found between scores in this scale with the estimates of the adjustment of gunners made by psychologists on the basis of an interview with 210 members of class 44-4, at Buckingham. The reliability of the judgments of the interviewers with reference to the adjustment of the subjects was estimated to be 0.79, using the Kuder-Richardson Formula 21.

The fact that the attitude scale was not significantly related to various criteria of performance in gunnery training does not definitely invalidate the scale as a possible instrument for the selection of gunners. The need for using combat performance data was recognized to be especially great in the case of attitude studies, but the validation of this scale against combat criteria was never accomplished.

Studies of biographical data blanks.—Another possibility explored was the Biographical Data Blank.[11] The Biographical

[11] This work was primarily the responsibility of Capt. Lawrence M. Stolurow, Lt. William B. Schrader, Cpl. David Gordon, and Pfc. Arthur Feiner.

Data Blank, CE602D, was developed in the aviation cadet classification program. In the initial tryout, the only modification introduced was the substitution of "Gunnery Training" for "Aviation Cadet Training" in 2 of the 65 items. The remaining items covered general matters of personal experiences and activity preferences. In this form, the blank was administered to 315 gunnery students during the fall of 1943, and an item analysis made by correlating of the various items with total score on Gunnery Final Examination (Form GFC). A new scoring system for the blank was developed in accordance with evidence obtained from this item analysis. The blank was lengthened by adding 2 items on experience with firearms, 8 items on experience with small group leadership and teaching, and 1 item on attitude toward being a gunner.

Results on the usefulness of this revised blank in predicting various criteria have been reported on page 76 in connection with the experimental test battery used for class 44–4, Buckingham. It was found that the validity coefficients for this instrument were uniformly low. On the strength of this exploratory study, it was decided that the use of biographical information of the type included in the Biographical Data Blank was not particularly promising. Effort was directed toward the development of other instruments.

Studies of forced-choice inventories.—In further exploration of means of measuring personality as it might be related to success in gunnery training, an investigation was made of the possible utility of an instrument similar to the Personal Inventory, DE201C.[12] The inventory used in this study was a revision of the original form, as modified for the Army by the AAF Redistribution Center, Atlantic City, in March, 1944. The inventory consisted of items related to past experiences, to preferences, and to interests in various occupations and hobbies. The items covered certain areas designated as habits, temperament, hysteria, hypochondriasis, school, family, occupation, values, paranoia, interests, and phobias. Candidates were required to choose between two alternative statements, which, in many cases, were not logically related to each other. Thus, a choice was forced between alternatives difficult to compare. Examples of items from the inventory are:

I would rather see a good movie.	I would rather read a good book.
I am more noisy.	I am more lazy.

The original format of the Personal Inventory was retained in

[12] This work was primarily the responsibility of Lt. Gerald R. Pascal and T/Sgt. Hyman Kaltz.

the experimental form, although experience later suggested that a standard multiple-choice format would have been more readily read and scored.[18]

The revised inventory was given to a mixed group of 30 combat returnee enlisted men and 106 noncombat enlisted men. The results of this study are presented in table 6.15. It can be seen that the ex-combat men obtained higher scores on the inventory, which was indicative of greater maladjustment within this group. The difference between the mean scores of the two groups was significant, the probability of such a difference occurring by chance being less than five times in one hundred.

TABLE 6.15.—*Validity of the revised personal inventory, DE201C; mean scores obtained by ex-combat men, and men with no combat experience (Buckingham, April 1944)*

	N	M	SD	Diff	t
Ex-combat men	30	15.20	4.40	2.41	[1] 2.43
Noncombat men	106	12.79	4.84		

[1] The obtained value of t is of a size to be expected to arise by chance less than 5 times in 100.

The same groups were given the Opinion Poll, which was described on page 81, in order to determine whether ex-combat men and noncombat men could also be differentiated on the basis of their attitudes. The difference between the mean scores of the two groups on the Opinion Poll was not significant. (A "t" value of 1.22 was obtained; a "t" value of 1.96 would be required for significance at the 5 percent level). The two groups were therefore distinguishable on the basis of adjustment as measured by the Personal Inventory but were not distinguishable on the basis of attitudes, as measured by the Opinion Poll.

The next step in this study of the Personal Inventory was to investigate the relative significance of various groups of items. Items were categorized into various areas, as indicated in table 6.16. The data in table 6.16 suggested that the areas of temperament, hysteria, and habit were most significant in discriminating between ex-combat men and noncombat men. Further developmental work on an inventory of the type described seemed indicated.

Summary.—In summary, it was concluded that the exploratory studies conducted in the areas of attitude and adjustment measurement were promising and little more. Results on the Opinion Poll indicated that fairly reliable scores could be obtained on this test, and that these scores showed a moderate degree of relation-

[18] For further information on the revised Personality Inventory and the procedures used in the revision, see report No. 14 of this series.

ship with interviewers' judgments on attitudes. The correlations of these scores with selection tests and available gunnery criteria, however, were uniformly low.

TABLE 6.16.—*Number of items from revised personal inventory, DE 201C, classified in each of 11 types which correlated with total score at the 5 percent level and 1 percent level of significance (N=136, including 30 returned combat gunners; Buckingham, April 1944)*

Type of item	Number of items	Number discriminating at 5 percent level[1]	Number discriminating at 1 percent level[1]
Temperament	7	7	7
Hysteria	14	9	8
Habits	9	6	4
School	5	1	1
Family	2	0	0
Occupational	6	0	0
Values	2	2	2
Paranoia	1	0	0
Interest	2	0	0
Phobias	3	3	2
Sociability	8	4	2
Total	59	32	25

[1] An item was considered acceptable at the 5 percent level if the point-biserial coefficients were sufficiently large to be expected to arise by chance less than 5 times in 100; at the 1 percent level, less than 1 time in 100.

STUDIES OF THE VALIDITY OF APTITUDE TESTS USING GUN CAMERA SCORES AS CRITERION

Studies of the prediction of proficiency on gun camera performance, carried out in the summer and fall of 1944 in cooperation with the AAF School of Aviation Medicine, differed from earlier studies chiefly in the greater attention given to questions of experimental design and control and in the relatively small number of subjects used.[14] Two separate studies were carried out, in each of which 16 graduate gunners trained on the Martin turret and 16 graduate gunners trained on the Sperry upper turret were used. The two studies were uniform in design up to the completion of the third gun camera mission. Moreover, it turned out that the variation introduced after the third mission in the second study produced no statistically reliable shifts in gun camera proficiency. It was possible to combine results from the two studies in the analysis of the effectiveness of prediction, although the studies were conducted at different times. However, for a few of the tests used, it was found that the test performance of the gunners tested later differed from that of the group tested earlier by a statistically reliable amount (CR greater than 3.0), so validity

[14] These studies were carried out under the supervision of Capt. Moncrief H. Smith of the School of Aviation Medicine and Capt. Mason Haire. They were assisted by T/Sgt. Riner Payne.

coefficients for these tests were computed separately for each study.

Printed tests included in this study were: SAM Arc Estimation, Rad Distance, and Rad Length Test (no code); SAM Angular Judgment Test, Parts I, II, III (no code); and Speed of Identification Test, CP610A. Apparatus tests included: Electronic Pilot Pursuitmeter, CM815A; Timing Reaction Test, CM504B; SAM Visual Coincidence Reaction Time Test, CP613B-3; SAM Two-Hand Pursuit Test (Thurstone), CM810A; and SAM Self-Pacing Discrimination Reaction Time Test, CP611E. In addition, three synthetic trainers used in gunnery were administered as possible selection tests. These included: Panoramic Gunnery Trainer (DeVry), Mark II; Jam-Handy (E-14) Trainer; and the E-8 Spotlight Trainer. All apparatus tests, including the gunnery training devices used as tests, were timed to give each man 8 to 10 minutes of performance. The same battery of tests was given to Sperry and Martin gunners, except that the Sperry gunners were tested on an E-8 Spotlight Trainer modified to permit the use of Sperry equipment. It was found that scores on the Panoramic Trainer and on the Electronic Pilot Pursuit Test varied sufficiently in the two studies to prevent data being combined for the calculation of validity coefficients.

The gun camera scores used in this study included were different for Martin and Sperry gunners. For Martin gunners, two scores were used: circular error scores, which measured in mils the gunner's deviation from the correct point of aim; and "percent hits," the proportion of scored frames in which the gunner's point of aim was within a distance of 15 mils from the correct point of aim. For Sperry gunners, three scores were used: tracking error scores, the distance in mils from the center of the sight to the nose of the attacking plane; framing error scores, the absolute magnitude in mils of the difference between the wingspan of the plane and the separation of the vertical extensions of the sight reticle; and tracking and framing errors, the sum of the two. A more detailed description of the scoring procedures is presented in the gun camera section of chapter 9.

The reliability of gun camera scores for three missions was estimated to be in the 0.60's for both Martin and Sperry scores. Reliability for all six missions was somewhat higher. Further discussion of the problems of determining reliability of gun camera scores and further data on the various estimates of reliability obtained are presented in chapter 9.

Validity coefficients obtained in this study were uniformly low. Only the SAM Two-Hand Pursuit Test (Thurstone), CM801A, showed promise of predicting proficiency for both Sperry and

Martin gunners. For this test, the validity coefficients for predicting scores on the first three missions (Martin) and the scores on all six missions (Martin) and for predicting combined tracking and framing on all six missions (Sperry) were sufficiently large to be expected to arise by chance less than 5 times in 100 in each instance. Although these studies were as carefully controlled as possible, the difficulties of maintaining uniform conditions for gun camera firing and the small number of cases prevented the establishment of any clear cut conclusions from the results obtained. The validity coefficients obtained are presented in Tables 6.17, 6.18, and 6.19.

THE SELECTION OF B–29 GUNNERS

The evidence from combat theaters and from research projects, as summarized above, was clear in indicating deficiencies in the existing program of selection of gunners. With the advent of training of gunners for very heavy bombers, a concerted effort was made to establish a more effective selection program. The

TABLE 6.17.—*Correlation of test scores with gun camera scores: Martin turret (32 Martin gunners: July-September 1945)* [1]

Test	M	Circular errors		Percent hits		
		Missions		Missions		
		1–3	1–6	1–3	1–6	1–6
Arc estimation test:						
Total score	85.28	0.08	0.05	−0.12	−0.13	−0.12
Part I	27.84	.18	.16	−.01	−.00	.00
Part II	8.31	−.05	−.13	−.14	−.22	−.22
Part III	29.18	.00	−.06	−.13	−.09	−.09
Angular judgment:						
Total score	48.47	.08	.09	−.02	−.01	−.01
Part I	21.82	−.01	−.03	−.08	−.10	−.01
Part II	12.97	.80	.28	.28	.24	.24
Part III	13.69	−.06	.02	−.20	−.10	−.10
Speed of identification CP610A	38.31	.16	.25	.18	.32	.32
Visual coincidence CP613B–3	43.91	−.15	.03	−.20	.05	.05
Two-hand pursuit (Thurstone), CM810A.	575.72	.40	.43	.34	.36	.36
Self-pacing discrimination reaction time test, CP611E.	397.54	.20	.33	.18	.32	.32
Timing reaction test, CM504B:						
Correct responses	79.12	.22	.18	.13	.10	.10
Errors	128.41	−.14	−.13	−.14	−.10	−.10
Jam-Handy trainer	6.68	.12	.19	.01	.07	.07
Spotlight trainer	3,565.40	.07	.07	−.04	.01	.01

[1] Signs of coefficients have been adjusted so that a positive correlation indicates that "goodness" of performance on the test is associated with "goodness" of performance on the criterion.

For N=32, a coefficient as large as .35 would be expected to occur by chance 5 times in 100; and a coefficient as large as 0.45 would be expected to occur by chance 1 time in 100.

TABLE 6.18.—*Correlations of test scores with gun camera scores: Sperry turret (32 Sperry gunners: July-September 1945)* [1]

Test	M	Correlations					
		Tracking		Framing		Tracking and framing	
		Missions		Missions		Missions	
		1–3	1–6	1–3	1–6	1–3	1–6
Arc estimation test:							
Total score	89.60	0.19	0.01	0.10	0.02	0.20	0.02
Part I	90.62	.27	–.06	.17	.12	.31	.08
Part II	28.94	–.09	–.10	.33	.10	.20	–.01
Part III	30.03	.15	.12	–.18	–.11	–.03	–.02
Angular judgment:							
Total score	50.32	.04	–.05	–.08	.15	–.03	.06
Part I	21.78	.10	.09	.03	.27	.13	.21
Part II	14.75	–.02	–.20	–.18	–.15	–.17	–.21
Part III	13.78	–.03	–.06	–.07	.16	–.08	.06
Speed of identification, CP610A	42.03	–.26	–.08	.03	.19	–.10	.05
Visual coincidence, CP613B–3	41.75	–.13	–.08	.17	.31	.10	.14
Two-hand pursuit (Thurstone), CM810A.	585.91	.11	.37	.07	.35	.16	.43
Self-pacing discrimination reaction time test, CP611B.	412.00	–.15	–.08	.02	.11	–.04	.03
Timing reaction test, CM504B:							
Correct responses	73.78	.07	.27	–.18	.01	–.07	.13
Errors	103.22	–.02	–.23	.15	–.06	.07	–.10
Jam-Handy trainer	6.81	.14	.10	.06	.20	.12	.17

[1] Signs of coefficients have been adjusted so that a positive correlation indicates that "goodness" of performance on the test is associated with "goodness" of performance on the criterion.

For N=32, a coefficient as large as 0.45 would be expected to occur by chance 1 time in 100.

TABLE 6.19.—*Correlation of test scores with gun camera scores for each experiment for tests where scores differed from experiment I to experiment II (July-September 1944)* [1]

Test	Mean	Sperry gunners (N=16)					
		Tracking—missions		Framing—missions		Track and frame—missions	
		1–3	1–6	1–3	1–6	1–3	1–6
Experiment I							
Electronic pilot pursuit test, CM815A	1.49	–0.44	–0.45	0.12	0.03	–0.17	–0.21
Panoramic trainer:							
Hits	226.88	.22	.02	.02	–.33	.10	–.22
Percent hits	20.94	.21	.09	.12	.02	.21	.04
Time on target	631.56	–.16	–.01	.03	.33	.08	.26
Spotlight trainer	-------	–.24	–.05	–.16	–.13	–.26	–.12
Experiment II							
Electronic pilot pursuit test, CM815A	2.26	.37	.42	.12	.41	.36	.60
Panoramic trainer:							
Hits	105.19	.19	.23	.08	.32	.20	.43
Percent hits	11.18	.19	.45	.10	.20	.21	.47
Time on target	354.00	.17	.39	.14	.29	.24	.48

[1] Correlations were computed for each experiment separately for all tests on which mean score in the two experiments differed by an amount, so large as to be expected to arise by chance less than 1 time in 1000 (CR of 3). Signs are adjusted so that a positive r indicates that "goodness" of performance on the test is associated with "goodness" of performance on the criterion. For N=16, an r as large as 0.50 would be expected to occur by chance 5 times in 100; and an r as large as 0.62, 1 time in 100.

Test	Mean	Martin gunners (N=16)			
		Circular error—missions		Percent hits—missions	
		1–3	1–6	1–3	1–6
Experiment I					
Electronic pilot pursuit test, CM815A	1.27	0.07	−0.15	−0.03	−0.20
Panoramic trainer:					
Hits	191.94	.08	.20	.09	.22
Percent hits	18.50	−.15	−.10	−.23	−.13
Time on target	622.44	−.22	−.08	−.31	−.12
Experiment II					
Electronic pilot pursuit test, CM815A	2.73	.29	.35	.31	.31
Panoramic trainer:					
Hits	95.19	−.16	−.14	−.17	−.07
Percent hits	7.75	.05	.02	.03	.11
Time on target	274.06	−.10	−.09	−.12	−.04

program set up for the selection of B–29 gunners was based on information obtained from the studies on the selection of gunners for light, medium, and heavy bombers, and it was patterned on the selection program used for the classification of aviation cadets. The objective of the program was to select, from the available personnel for gunnery training, those men who were most likely to succeed as B–29 gunners.

Deficiencies in training accented the need for proper selection. Many practical difficulties, such as shortages in equipment and in trained instructors, prevented the immediate institution of a standardized training program for B–29 gunners. This made it all the more important that a carefully designed and executed selection program be used if combat requirements for good gunners were to be even approximated.

Although stanines for the various light, medium, and heavy bomber gunnery jobs were introduced in the aviation cadet selection and classification battery in September of 1944, these scores were not actually used at first for the classification of gunners. Gunnery training absorbed all available manpower after men had been selected for other types of training. Since the number of men to be trained as B–29 gunners constituted only a small proportion of the total number of gunners to be trained, it was possible to select men of the highest caliber for this difficult and responsible job. Thus, for the first time, early in 1945, a program for the selection of gunners could be applied. After several months, the ratio of B–29 students to other gunnery students increased, and, in addition, the total number of gunners to be trained dropped off. However, during most of the period from January 1945 until the end of the war, the pool of candidates for gunnery training was divided into two general categories, B–29 gunners and other gunners.

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On 9 December 1944, a directive was sent to the AAF Training Command and subsequently to the Central School for Flexible Gunnery, by Headquarters, Army Air Forces, indicating the desirability of carefully classifying men to be trained as B-29 gunners. It was pointed out that the job of the B-29 gunner in operating remotely-controlled turrets was more complex than the job of the gunner operating locally-controlled turrets which were mounted on a bomber which flew at slower speeds and at lower altitudes than did the B-29. It was directed that all candidates for B-29 gunnery training take the aviation cadet selection and classification battery and be given gunnery stanines in accordance with certain prescribed procedures.

In carrying out this directive, the problem of selecting B-29 gunners was broken down into two specific problems, each of which required a different solution because of basic differences in the population to which they applied.

One of these problems involved setting up a permanent program for the selection of B-29 gunners. This problem was met by determining a routine procedure for selection prior to the entrance of candidates into B-29 gunnery schools or into a technical school which led to gunnery training. This selection program was accomplished by a method similar to that in use for the selection of bombardiers, navigators, and pilots.

The second problem involved setting up a temporary program for the screening of potential B-29 gunnery school candidates from men already committed to some type of technical training. These men were in a technical school and thus had passed beyond the stage at which they could have been economically rerouted through usual classification processing. An effort was made to select the best qualified men to proceed to B-29 gunnery training upon completion of their technical training. No single procedure for the selection of these men was possible; therefore, specific procedures had to be worked out to fit the particular circumstances in each area of technical training. This temporary program of selection was terminated as soon as the permanent program became fully effective.

The permanent program for the selection of B-29 gunners followed the procedures diagramed in figure 6.1. Once technical training schools had been exhausted as a source of men to be trained as B-29 gunners, there were three normal sources of supply of candidates for this type of training, the AAF Basic Training Centers, the AAF Personnel Distribution Command, and enlisted permanent party personnel of stations in the AAF Training Command. The Basic Training Centers supplied men who had passed the Air Corps qualifying examination and who were cur-

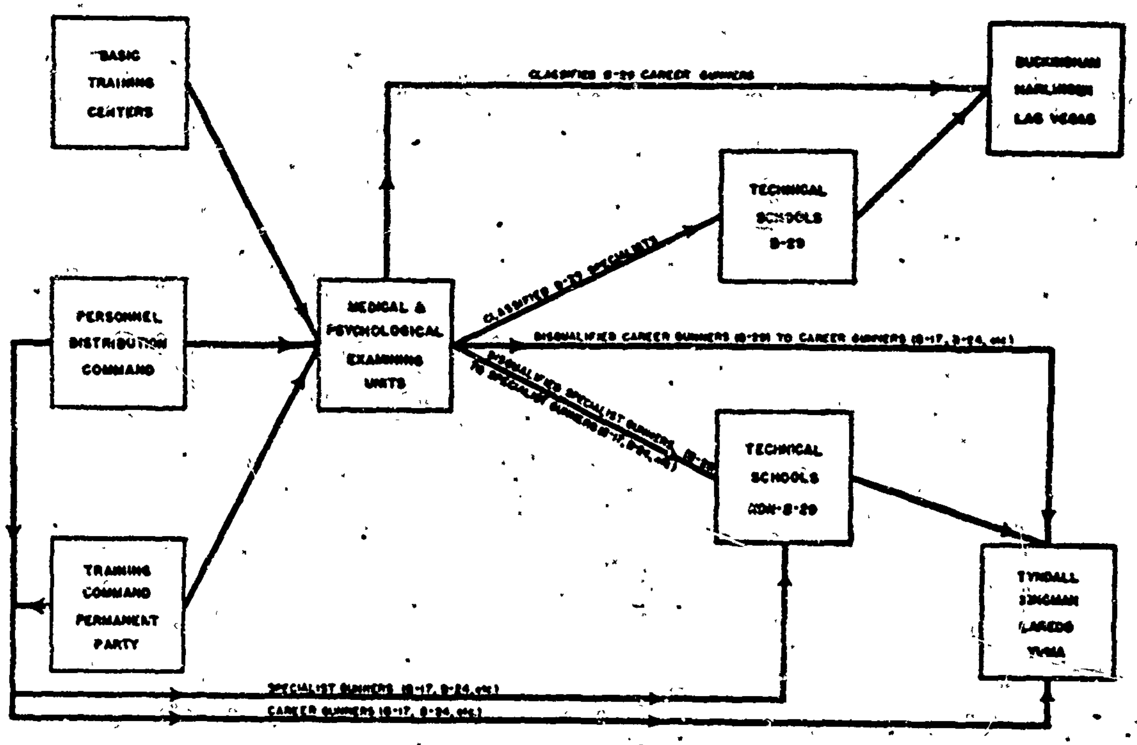

Fig. 8.1—FLOW SHEET FOR PROGRAM FOR THE SELECTION OF B-29 GUNNERS, SHOWING FLOW THROUGH PSYCHOLOGICAL EXAMINING UNITS TO B-29 SCHOOLS AND TO OTHER SCHOOLS (1 NOV. '44)

rently reaching the induction age. The total number of men in the Basic Training Centers who were qualified at the time of the initiation of the B–29 selection program was approximately 40,000 men. Of this total, approximately 70 percent failed to qualify for training as bombardiers, navigators, or pilots. The flow from the Personnel Distribution Command materially decreased as time went on and eventually became an unimportant source of candidates for gunnery training. The flow from permanent party personnel was rather sporadic and unpredictable and did not constitute a major source of personnel. Thus, after the initiation of the B–29 selection program, the chief sources of personnel for gunnery training were the Basic Training Centers.

The program designed for the temporary selection of B–29 gunners required that all men who were in technical schools and who had not previously taken the aviation cadet selection and classification battery be examined. Students in the airplane mechanics schools at Keesler Army Air Field and Amarillo Army Air Field were tested at the Medical and Psychological Examining Units already in operation at those stations. Students in the pregunnery remote-control turret courses and in the pregunnery armorer courses at Lowry Army Air Field were tested at the Medical and Psychological Examining Unit No. 9, which was reopened for the special purpose of examining these men.[15]

The scores used for the screening of B–29 gunners were determined on the basis of the number of men needed for B–29 training and the percentage of candidates who could be expected to qualify for training on the basis of the scores established. The minimum aptitude scores used were as follows:

For training as a B–29 Career Gunner and Armorer Gunner, a stanine of six (6) or above.

For training as a B–29 Remote-Control Turret Gunner, or as a B–29 Airplane-Electrical Mechanic Gunner, a Mechanic-Armorer Gunner stanine of six (6) or above.

For training as a B–29 Armorer Gunner, a Mechanic-Armorer Gunner stanine of five (5) or above.

For men who had been tested with the aviation cadet selection and classification battery prior to 1 September 1944, and for whom there were no recorded gunnery stanines, a bombardier stanine of 5 was used for minimum requirement for B–29 gunnery training. Men returning from combat who were candidates for B–29 gunnery training were retested if they did not have a gunnery stanine. At first, combat returnees were given a one stanine point bonus but this procedure was later done away with. Effective 26 March, 1945, the aptitude requirements for all B–29 gunnery specialist

[15] For a description of the battery used and procedures followed in administration, see Report No. 2 in this series.

positions were changed to require an Armorer Gunner Stanine of five (5) or better. For men previously tested and for whom the Armorer Gunner Stanine was not available, a Bombardier Stanine of five (5) or better was substituted. On 1 July 1945, when a new classification battery was introduced, a minimum Aerial Gunner Stanine of five (5) was required for all types of very heavy bombardment gunnery training. The processing of men for the B-29 gunnery training program began in January, 1945, and continued until shortly after the capitulation of Japan.

ELIMINATION PROCEDURES IN AAF TRAINING COMMAND GUNNERY SCHOOLS

Introduction

The problem of selection of gunners was considered to include not only selection by tests prior to training but also the selection which occurred through the operation of elimination policies in the gunnery schools. Improvement in elimination procedures was considered desirable as a means of improving the average proficiency of gunners assigned to combat crews.

First Proposals for Improvement in Elimination Procedures

Early attempts to effect improvement in elimination procedures stressed two basic points: (a) the motivational value of a definite elimination policy, and (b) the need for a standard procedure of elimination, designed so that a gunner's prospects of elimination would depend on his proficiency, and not upon the particular school or class in which he received his training.

As an argument for at least some type of elimination policy, especially since some schools were eliminating very few students, it was urged that creating a training situation involving the definite possibility of failure and elimination would increase the motivation of students. Five percent elimination was arbitrarily set, on the basis of the best available judgment, as the minimum percentage desirable in basic gunnery training.

The various types of measures that each school was employing at this time as grounds for elimination were reviewed, and it was decided that the most promising, in terms of relevance to gunnery proficiency and amenability to standardization, were (a) air firing scores, (b) ground firing scores, and (c) academic grades. It was further suggested that those students be considered for elimination who stood in the lowest 4 percent of their class in air firing proficiency, in the lowest 4 percent in ground firing proficiency, and in the lowest 2 percent in academic proficiency. It was also proposed that each school continue its own method of scoring in

these areas until some standardized methods for use in all schools could be developed. Late in 1943, this suggested policy became the official policy for elimination from basic gunnery training as stated in directives issued by Headquarters, AAF Training Command.

Attempts at Standardization

Investigations of air-to-air and ground range firing.—The first investigations of air firing at Harlingen and Laredo led to the strong impression that air firing scores were extremely unreliable, due to the large number of uncontrolled factors operating in this situation, as has already been noted in chapter 5. A similar situation was found to exist in ground range firing. Firing was conducted under a variety of conditions, and scoring was not always carefully supervised. Schools differed with respect to the type and size of target used. Attempts were made to persuade training officers at the various schools to standardize air and ground firing situations. In addition, a form for reporting scores weekly to the Instructors School was prepared and distributed. On the basis of the returns each week, statements were sent out to all gunnery schools summarizing the differences in scoring and in elimination rates among schools, as one means of pointing out the need for standardization.

Construction of achievement tests.—Variations among schools in the measurement of gunnery knowledge was reduced by the development and adoption of the Gunnery Final Examination (discussed in chapter 7). The use of scores on this examination as a basis for elimination was directed by AAF Training Command.

Survey of Elimination in Gunnery Schools

In December 1943, a survey was made of student elimination in five successive classes in each of six gunnery schools. The results of this study are presented in table 6.20. It was found that marked variations in percent eliminated appeared among the schools and among classes in the same school. Scores obtained from administration of the Gunnery Final Examination for each school varied appreciably from school to school, so that the application of a fixed cut-off score on this test would have resulted in marked variations in percentage of students eliminated in the different classes.

There was, however, no reason to believe that the method of assigning gunners to schools would result in marked variations in gunnery ability from school to school or from class to class. As a check on this viewpoint, examination was made of mean Army General Classification Test scores in four successive classes

TABLE 6.20.—*Percent of students eliminated for various gunnery deficiencies at six basic gunnery schools, five classes (October-November 1943)*[1]

PERCENT ELIMINATED FOR AIR-TO-AIR FIRING DEFICIENCY

Class	Buckingham	Laredo	Harlingen	Las Vegas	Kingman	Tyndall
43-43	0.00	1.35	2.30	0.36	2.20	0.86
43-44	.00	1.60	2.10	.37	.00	1.59
43-45	.00	4.41	3.10	.18	.63	.00
43-46	.00	.00	.40	.90	2.50	3.24
43-47	.00	1.61	1.30	1.10	.00	2.32
Mean	.00	1.79	1.84	.58	1.07	1.60

PERCENT ELIMINATED FOR GROUND FIRING DEFICIENCY

Class	Buckingham	Laredo	Harlingen	Las Vegas	Kingman	Tyndall
43-43	0.20	0.00	0.00	0.00	1.00	0.69
43-44	1.93	.00	.00	.00	.00	.37
43-45	1.05	.00	1.00	.00	1.06	.00
43-46	.48	.00	.70	.00	.56	1.94
43-47	.40	.00	.80	.18	.00	2.38
Mean	.71	.00	.50	.04	.52	1.28

PERCENT ELIMINATED FOR ACADEMIC DEFICIENCY (AS MEASURED BY GUNNERY FINAL EXAMINATION, FORM C)

Class	Buckingham	Laredo	Harlingen	Las Vegas	Kingman	Tyndall
43-43	1.01	1.30	3.70	0.18	5.73	3.94
43-44	1.74	3.89	6.40	.00	.00	5.68
43-45	1.05	1.47	5.40	.56	1.06	1.54
43-46	.00	1.58	2.90	.18	1.25	1.51
43-47	.00	2.15	3.10	.36	.00	1.27
Mean	.87	2.18	4.30	.26	1.61	2.79

PERCENT ELIMINATED FOR AIR-TO-AIR FIRING GROUND RANGE FIRING AND ACADEMIC DEFICIENCY

Class	Buckingham	Laredo	Harlingen	Las Vegas	Kingman	Tyndall
43-43	1.21	3.15	6.00	0.54	8.93	5.19
43-44	3.67	5.49	8.50	.37	.00	7.62
43-45	2.10	5.88	9.50	.74	2.75	1.54
43-46	.48	1.58	4.00	1.08	5.31	6.69
43-47	2.10	6.45	5.20	1.64	.00	7.97
Mean	1.86	4.51	6.64	.87	3.40	5.86

[1] The N's in all cases are approximately 400.

at Buckingham. The variations obtained as shown in Table 6.21 did not indicate that large shifts in ability were occurring as far as this index was concerned.

TABLE 6.21.—*Army general classification test scores for four successive classes (Buckingham, July-August 1943)*

Class	N	M	SD
43-31	306	110.4	11.8
43-32	335	106.4	12.8
43-33	175	110.6	14.7
43-34	331	110.3	12.8

First-hand observation of testing, training, and firing conditions at the gunnery schools gave strong support to the view that the use of a relative system of elimination (a fixed percentage eliminated in each class) was superior to a static system (fixed

cut-off score on tests and ranges) in view of conditions existing in gunnery schools.

Changes in Elimination Standards

During 1944 and 1945, certain changes in elimination standards were brought about. Perhaps the most important of these changes resulted from the introduction of phase checks. (See chapter 8.) These instruments permitted the elimination of students deficient in the care of their equipment. Also, early in 1944, air firing scores were dropped as a basis for elimination because of their unreliability and because the development of Position Firing called attention to the lack of similarity between air firing and the gunner's job in combat. Although much effort was devoted to the development of gun camera procedure and scoring as a substitute for air firing, this measure was not developed to a point which would permit its routine use for eliminating gunners.

The conversion of phase check scores into a 5-point scale, with a converted score of 1 considered a failure, was relatively well received by the gunnery schools. Gun camera scores were interpreted by use of a similar conversion table. On the basis of this experience, a program for developing similar norms for various ranges and tests was under way at the close of the war. Such a development would have been a step in the direction of uniform elimination procedure.

Critique of Gunnery Elimination Procedures

Throughout the war, certain fundamental difficulties stood in the way of a rigorous uniform elimination policy. Although attempts were made, as described above, to improve elimination methods, these efforts did not succeed in eliminating the three basic difficulties described below.

1. *The lack of an established criterion of gunnery proficiency to provide a basis for elimination.*—It was pointed out in chapter 5 that adequate methods of measuring the ability of gunners to aim and shoot at attacking fighters were never established. It was also never found to be possible in training to simulate more than roughly the conditions under which the gunner performed his combat job. Thus substitute criteria, which were based on various devices and procedures used in training, remained inadequate. The elimination policy inevitably reflected the deficiencies in the substitute criterion.

2. *The need to graduate a relatively definite number of student gunners each week for assignment to combat crew training.*—The practical problem of always filling this need, which varied from

time to time, was solved to an extent by the creation of pools of graduates from which the training air forces could draw. The possibility of somewhat increasing the size of basic gunnery classes in the event that a greater elimination rate was deemed desirable was always limited by the barely adequate number of men available for possible training as gunners. Due to the rather rigid nature of the military training situation, there was always the necessity of graduating a minimum number of students each week from each school, regardless of the proficiency of the men graduated. This forced attempts at reduction of variability in elimination rates and also encouraged the graduation of an excess number of men in each class, a practice which never incurred censure as did the failure to meet a quota.

3. *The lack of strict enforcement of elimination procedures.*—Each gunnery school in the AAF Training Command developed with a certain degree of autonomy. This fact usually lead to compromises between programs of strict, specific standardization, urged by individuals in the Central School, and the more or less *laissez-faire* approach desired by local school authorities. The result was that the schools conformed to certain broad requirements in the determination of elimination, but to a considerable extent eliminated whom they pleased in a way that pleased them.

SUMMARY

Efforts at research in gunnery selection were handicapped by two major problems: first, the difficulty of obtaining adequate criteria for the validation of gunnery selection devices; and second, the stringent limitations upon the amount of selection of gunners which could actually be done during most of the war. The early validation studies indicated that the acquisition of gunnery knowledge could be predicted with moderate success, but the effectiveness of tests for predicting skill in the use of equipment remained unknown because of inadequacies found in the criteria used. Efforts at obtaining better criteria for use in validation led to extensive changes in various phases of gunnery training described elsewhere in this report, but did not achieve the goal of providing adequate criterion measures. The most elaborate experimental studies, using gun camera scores as a criterion, although based on a relatively small number of cases, suggested that skill in use of equipment was not likely to be predicted with a high degree of validity by the carefully selected performance tests tried out. With regard to gunnery selection, the various studies were useful in determining stanines for the selection of B-29 gunners.

Finally, the predominantly negative results obtained in most studies served to stress the importance of concentrating effort upon the improvement of gunnery training as the more promising approach to the improvement of gunnery proficiency.

CHAPTER SEVEN

The Development of Achievement Tests

Capt. LAWRENCE M. STOLUROW

ROLE OF TESTING IN FLEXIBLE GUNNERY PROGRAM

Achievement Testing in the Flexible Gunnery Program

The role of achievement tests, although relatively insignificant in the early months of flexible gunnery training, gradually grew in scope and importance as the war went on. In general, the various uses that were made of such tests, and the varying emphasis that was placed on them, tended to reflect more basic and underlying changes that were occurring in the training of gunners. It is convenient, therefore, to consider the changing role of tests in terms of three broadly defined periods of gunnery training. The first of these was a period characterized by many differences in instruction and in testing procedures among the basic gunnery schools; the second, a period in which attempts were made to make the instruction and testing of gunners more uniform through indoctrination of instructor personnel; and the third, a period in which both instruction and testing were relatively standardized, and were controlled to a considerable extent by policies and specific directions emanating from the Central School.

Period of decentralized instruction and testing.—The early training of flexible gunners was governed by certain requirements, in terms of subject matter, training procedures, and hours of instruction, that were set forth in directives, but classroom instruction was a highly individualistic affair. Instructors prepared their lesson plans and organized their courses with a minimum of supervision and guidance. As part of their duties, they developed written examinations, administered them, scored them, and appraised the results. All of these steps were likely to be performed in a multitude of haphazard ways, reflecting the limited back-

ground and ingenuity of individual instructors; even elementary statistical considerations were usually ignored. Some schools used tests prepared by their own personnel as one basis for evaluating the final achievement of students and for eliminating the poorest students (see chapter 6), but most instructors looked upon achievement tests with misgivings as to their importance and as a rule did not take them seriously.

The general level of achievement testing in gunnery in late 1942 is indicated by the following quotation from a report describing tests used at Las Vegas:

a. Length of examinations.—For the most part examinations have been extremely short, i.e., some final examinations consist of 15 or 20 objective questions.

b. Types of questions in examinations.—The examinations contain many true-false and completion items. Many of the questions are so obvious as to require little knowledge of the subject matter of the course. No attention has been paid to the gradation of questions in terms of difficulty.

c. Weights of items in examinations.—No good rationale has been discovered for the weights assigned different items in a test. It is reported that sometimes the weights are assigned by the instructor in the course. This would be a source of unreliability inasmuch as several instructors teach the same subject.

d. Administration of examinations.—Reports have been made that often the instructor goes over the exact questions to be asked just before the examination. Evidence for collaboration among students appears to be plentiful.

e. Scoring of examinations.—A very considerable number of errors in scoring the examinations was noted in the studies of reliabilities made to date. Rescoring was necessary in all cases.[1]

Attempts to standardize training and testing.—At the same time that attempts were made to standardize all areas of gunnery training, so that all gunners would know how to do their job in the same way, efforts were devoted to improving the examinations used in the gunnery schools and to making them more uniform. Because the construction and administration of examinations was the responsibility of instructors at each school, first efforts in this direction consisted of indoctrinating instructors in the fundamentals of test construction. A manual entitled "How to Construct a Test" was prepared in 1943 by personnel of the Psychological Research Detachment (Gunnery), and provided the basis for such indoctrination in the Central Instructors School.[2] In this manual, instructors were urged to take the following factors into account when preparing achievement tests for use in their courses:

1. The necessity of adequately reflecting the content of the course in each test, without undue emphasis being placed on only a few aspects of the course.

[1] This report was prepared by Maj. Clarence W. Brown, director of Psychological Research Detachment at Las Vegas.

[2] This manual was prepared by Maj. Roger W. Russell.

2. The desirability of using objective type questions, in order to save time in administration and scoring, and to make scoring more standard. Multiple-choice questions were recommended as being most applicable to gunnery subject matter, although the use of true-false and matching questions was discussed and recommended in certain cases.

3. The desirability of expressing each question as clearly, simply and briefly as possible.

Although these attempts at indoctrination in testing procedures were elementary, it was noted that some instructors improved in their ability to make effective use of achievement tests. Most instructors, however, continued to use tests simply to verify classroom impressions of students. More attention was paid to item construction and validity than had been true in the past, but little more than lip-service was paid to the proper technique and procedures of standardized test administration.

Period of centralized testing.—With the gradual standardization of course content and training procedures, it became possible to prepare centrally some examinations that could be used in all schools. This was felt to be desirable for two main reasons: such examinations would serve to provide relatively standard measures useful in standardizing instruction and evaluating student achievement and they could be constructed by personnel with specialized testing experience. Early forms of a final comprehensive examination, embracing all course material taught in basic gunnery schools, were prepared by personnel in Psychological Research Unit No. 11 (Gunnery), and were directed for use in all schools. There was some resistance to the use of such standardized examinations at first, but their use was gradually accepted and they became an integral part of the training program.

Once standardized examinations had been developed for use by all schools, the indoctrination of instructors and supervisory personnel in testing procedures shifted from an emphasis on the techniques and principles of test development to the proper administration of examinations, and the correct interpretation of results.

A manual, "Written Examinations," which covered the procedures to be used in the administration and the scoring of tests, the analysis of data, and the reporting of results, was prepared and distributed to the instructors at all of the gunnery schools. The manual provided a check list for the test administrators and proctors indicating each of the steps to be accomplished before the test was given, when it was given, and after the test was over.

Instructors became less important in testing because most schools began to use separate personnel for the administration and scoring of tests. The Central School became responsible for the

development and revision of tests, the supervision of their publication, the preparation of directions for their administration and scoring, the establishment of norms, and the construction of certain statistical report forms.

Uses of Achievement Tests in Flexible Gunnery Program

During the later period of gunnery training, the Final Comprehensive Examination provided the most reliable scores on which to base graduation and elimination, and this became its primary function. Its use for this purpose tended to increase the motivation of students, and also to enforce a standardized program of gunnery instruction.

The error item analysis report form.—In order to make the Final Comprehensive Examination an instrument of standardization, an "Error Item Analysis Report Form" was developed. This form contained the information indicated by the following headings: "Item number;" "Number of students who missed the question," "Information covered by the Item," "Where covered in the lesson plan," and "Where covered in Gunners Information File." If the test had more than one comparable form, the question numbers of both forms were indicated. The description of the information covered by the item was always expressed in a general way with as little as possible of the actual item included. The lesson plan reference indicated the course hours during which the particular material was covered. The Gunners Information File reference indicated a page or group of pages which covered the item and related background material. Technical Order references were given when information was covered by the lesson plan but not by the Gunners Information File. The form was accomplished by the test administrators and proctors, and the instructors were not permitted to see the examination at any time. The completed forms were made available to instructors and to supervisory officers.

Once weaknesses were indicated by a relatively high frequency of student errors, the instructor could refer to the sources indicated and in this way take corrective action in his instruction to subsequent classes. The form also tended to bring to the attention of supervisory personnel the number of students missing each item in the examination, and this in turn provided a ready means for evaluating the effectiveness of each instructor as well as the adherence of the department as a whole to the standardized lesson plans. Copies of the form were retained on file at the school for reference by inspection personnel who were to use it to find persistent instructional weaknesses for which there was no indication that corrective action had been taken.

Other uses of examinations.—The following lesser uses were also made of the Final Comprehensive Examinations and of the various course examinations prepared by the psychological test section of the Research Division:

1. They were used to provide periodical indications of instructional efficiency both within and among departments and schools.
2. They were used to provide scores showing relative scholastic standing of students.
3. They were used in the selection of student instructors and student gunnery officers.
4. They provided a criterion for the validation of selection tests.
5. They were used in curriculum evaluation studies and studies of the relative effectiveness of different teaching methods.

The effectiveness of early editions of the examinations was limited by the fact that some students became familiar with questions beforehand, sometimes due to coaching on the part of instructors and sometimes due to the circulation of questions among the students. Attempts were made to keep this leaking out of information about the examinations at a minimum by classifying all examinations as confidential, and revising them periodically.

Summary.—The development of the achievement testing program was characterized by a general trend toward the separation of the duties and responsibilities associated with testing from the personnel responsible for instruction, and the concomitant assumption of these duties and responsibilities by psychologically trained personnel. Personnel responsible for training were naive with respect to testing and were characteristically individualistic in their approach. Receiving gunners from two or three different basic gunnery schools made it difficult for the training and combat air forces to set up a stable training program since the gunners were supposedly trained for the same job but actually were trained differently. The standardiz tion of testing which was accomplished aided materially in standardizing training.

PROCEDURES USED IN DEVELOPING ACHIEVEMENT TESTS

Introduction

One of the principal functions of the personnel in the psychological tests section was the development and revision of achievement examinations. The Final Comprehensive Examination and course examinations were the principal achievement examinations developed. With the exception of aiding in motivation, course examinations were principally effective as diagnostic devices and as aids to more efficient learning. Initially, these examinations

were used rather extensively if not uniformly, and as a result played a relatively important part in the training program. Later on, the extent of their use dropped off considerably. This shift in use was correlated with changes in emphasis in training from verbalization to manipulation and motor skills, and with the introduction of phase checks to measure proficiency in these skills. With this rise in emphasis on the development of skills, less and less time was devoted to lecture and the presentation of theoretical materials. As a result the only achievement tests in general use in the gunnery program in 1945 were the Final Comprehensive Examination and the Caliber .50 Nomenclature and Part Function Examination, a course examination. The bulk of the work of the test section with respect to revising the Final Comprehensive Examination resulted from changes that occurred in gunnery subject matter, from the accumulation of item analysis data, and from the gradual dissemination of information about examination questions among students, discussed above.

The following discussion of procedures used in the development and revision of achievement tests will be based on work done on the Final Comprehensive Examination. Discussion will be oriented around the selection of test items and around statistical and editorial considerations.

Selection of Test Items

Sampling considerations.—A 2-hour period was allotted for final achievement testing in the basic gunnery school curriculum, and it appeared that an examination including from 135 to 150 multiple-choice questions would be most satisfactory for use during such a limited period. In order to distribute items equitably among the areas of subject matter, the following factors were taken into account:

1. The desirability of representing all significant aspects of the subject matter on the examination. This was accomplished and checked by reference to the detailed lesson plans on which each course was based.

2. The desirability of stressing those aspects of the subject matter that were considered to be most important, and that students found most difficult to master. These considerations were discussed and checked with personnel responsible for program planning and with individual instructors.

3. The desirability of stressing those aspects of the subject matter about which it was considered important for the gunner to be able to verbalize. These aspects were determined mainly by the judgment of members of the psychological test section.

Early forms of the Final Comprehensive Examinations were

organized in terms of four separate areas of subject matter: aircraft recognition, sighting, weapons, and turrets. The turret section was composed of several equivalent parts, each part covering one turret. The first three sections of the test were taken by all students. In the last section, the students answered the questions pertaining to the turret on which they had been trained. Later on, the section on aircraft recognition was replaced by a miscellaneous section devoted mostly to questions on crewmanship.

Sources of test items.—In the development of the original form of the Final Comprehensive Examination, and in subsequent revisions, questions were derived for the most part from the following sources:

1. Detailed descriptions of course material contained in lesson plans.
2. Technical literature regarding gunnery equipment and its use (especially The Gunner's Information File).
3. The course examinations developed and used by the individual gunnery schools.
4. Suggestions from instructors and supervisory personnel in the individual gunnery schools.
5. Suggestions from members of the psychological test section, most of whom had some gunnery background.

Statistical Considerations

Introduction.—The statistical analyses of results of administering the Final Comprehensive Examination were concerned with maintaining a high total-test reliability, achieving a high degree of sub-test homogeneity, and controlling the mean and dispersion of item difficulty.

Analyses were based on administration of an experimental or a final form of the examination to representative classes of students. As classes consisted usually of around four hundred students, it was possible in one administration to acquire suitable samples of scores for all except the turret parts of the examination. Obtaining a sufficient number of answer sheets for each turret part was made difficult by the fact that every class included students specializing in several different turrets, and the number of students specializing in each turret varied considerably from class to class and from school to school.

Discrimination indexes of test items.—Internal consistency indexes were determined for each item by use of a chart prepared for use in the Aviation Psychology Program.[3] The discrimina-

[3] This chart was constructed by Capt. Frederick B. Davis. *Cf.* Davis, F. B. *Item-Analysis Data: Their Computation, Interpretation, and Use in Test Construction.* Cambridge: Harvard Graduate School of Education, 1946.

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tion index obtained by this method varies from -100 to $+100$. In general a discrimination index of $+20$ or greater was used as the standard for acceptance of an item, but in some instances it was necessary to retain items on the basis of a minimum value of $+18$. Items with negative discrimination indexes were dropped.

The difficulty of test items.—Consideration was given to the difficulty of items as well as to their discriminating power. Items on which it was judged that too high or too low a proportion of students made the correct response were dropped from the test.

Improvement of wrong choices.—In tests made up of multiple-choice items, attention was given to the improvement of wrong choices. Primarily, this involved locating wrong alternatives which were infrequently chosen. The procedure by which alternatives in need of revision were identified was as follows: First, the proportion of incorrect responses to an item was divided by the number of wrong alternatives on the item; second, the value so obtained was divided by 2; third, any alternative which received a proportion of responses less than the value so obtained was selected for revision or replacement.

Editorial Considerations

In reviewing questions for inclusion in the Final Comprehensive Examination, a check was made to ensure that the wording of all questions was not much above the eighth grade level of reading comprehension, and that it was as clear and brief as possible. Each question was also checked against the current lesson plan to make sure that the point of the question was covered in the course. Technical questions were checked by individuals familiar with gunnery equipment, procedure, and training.

In general, questions were designed or selected to cover the following abilities or areas of information: knowledge of facts, principles, and procedures; application of facts, principles, and procedures to new or common situations; recognition, identification, and location of parts; and function of parts and groups of parts.

After all questions had been reviewed and approved, first drafts of the examinations were prepared, including directions for administration. In most cases, copies of the examination were locally reproduced and tried out before being printed for general distribution to all schools. Later forms of the Final Comprehensive Examination were printed in loose-leaf form, to permit the inserting of revised pages from time to time.

DESCRIPTION OF FLEXIBLE GUNNERY FINAL COMPREHENSIVE EXAMINATION

Introduction

The Flexible Gunnery Final Comprehensive Examination went through four major stages of revision, the various forms of the examination being designated as GF–A, GF–B, GF–C, GF–D, GF–E, and GF–F. GF–A and GF–B were comparable forms; GF–E and GF–F were equivalent forms. The areas of subject matter covered by all of these forms, the sources of items, and the general format were very similar. Improvement occurred in the sampling of subject matter, in the sensitivity of questions, and in the physical appearance and usability of the examination booklets. Each form consisted of about 150 multiple-choice type questions (five choices for each question), designed for administration in a 2-hour period, and with a separate answer sheet which could be machine scored. Scoring in all cases consisted of totaling the number of correct answers.

Forms GF–A and GF–B

Introduction.—The first form of the Final Comprehensive Examination, designated as GF–A, was completed on 6 June 1943, and was administered to classes 43–26 to 43–32, inclusive, at Buckingham. There was some delay in its printing, which necessitated the local reproduction of a temporary form, known as GF–B, for administration to class 43–25. This form did not include as many pictorial questions as GF–A, and was not used once the latter form became available. The following discussion will be based entirely on GF–A.[4]

Format. GF–A consisted of 4 parts and 150 questions, as follows:

Part I.	Aircraft recognition	30 questions
Part II.	Sighting	45 questions
Part III.	Weapons	45 questions
Part IV.	Turrets	30 questions
	Total	150 questions

Questions in the turret part were so worded as to apply to all turrets studied in the B–17, B–24, and B–25 training programs; the correct answer to each question would vary according to the turret specialty of the student, necessitating separate scoring keys for each turret. For example, question No. 121 was worded as follows:

[4] This test was developed by S/Sgt. Marvin Waldman, Lt. George J. Wischner, Maj. Roger W. Russell, M/Sgt. Jack D. Adams, and Lt. Arthur L. Irion.

121. **Your turret is mounted in the:**
   121-A. **B-24 and B-26.**
   121-B. **B-25.**
   121-C. **B-29.**
   121-D. **B-17E and B-17F.**
   121-E. **B-24 and PB2Y.**

This type of question could be used only to cover characteristics that applied to all turrets. The necessity of including alternates which applied to all of the different turrets, one of which was correct for each, conserved space but limited the effectiveness of the questions. It was therefore decided to include separate turret sections in subsequent forms, involving questions specific to particular turrets.

Sources and types of questions.—Copies of available gunnery tests, course syllabuses, technical orders, and manuals were studied for materials which could be used for questions GF-A. The test consisted principally of questions that involved verbalizations about gunnery theory, equipment, and procedures. A smaller number of questions included pictures, about which the student was required to identify something. A few questions were based on diagrams. A breakdown of the test in terms of each of these three types of questions is included in table 7.9.

Statistical data.—The distribution constants and reliabilities of GF-A, based on administration to seven classes, are presented in table 7.1.

TABLE 7.1.—*Reliabilities and distribution constants for GF-A total and part scores in various classes (Buckingham, June-July 1943)*[1]

	Class 42-26 (N=308)			Class 43-27 (N=324)			Class 43-28 (N=292)		
	M	SD	r	M	SD	r	M	SD	r
Aircraft recognition	17.96	3.65	0.46	20.40	3.18	0.36	18.48	3.83	0.52
Sighting	23.36	5.17	.58	29.81	5.05	.61	25.29	5.62	.65
Weapons	27.89	5.06	.67	30.79	4.50	.52	28.45	5.30	.63
Turrets	22.68	2.83	.31	24.21	2.09	.00	23.63	2.96	.43
Total[2]	93.57	13.27	.83	105.20	11.14	.75	95.87	14.04	.82

[1] All reliabilities computed by Kuder-Richardson Formula No. 21.
[2] Additional reliabilities and distribution constants for total scores are as follows:

Class	N	M	SD	r
43-29	301	100.35	12.51	0.79
43-30	354	103.95	12.41	.79
43-31	303	98.96	12.58	.67
43-32	395	100.90	12.88	.78

Form GF-C

Introduction.—GF-C was the first form of the Final Comprehensive Examination to be distributed to all of the gunnery

schools for their use in determining the graduation and elimination of students. It was printed in September, 1943, and was used until April, 1944. It contained many revisions of GF–A, based mostly on changes that had taken place in lesson plans and course content. Some technical errors and printing errors that had been found in GF–A were also corrected.[5]

Format.—GF–C included the following parts and numbers of questions:

Part I.	Aircraft recognition	25 questions
Part II.	Sighting	25 questions
Part III.	Weapons	50 questions
Part IV.	Miscellaneous	10 questions
Part V.	Turrets	40 questions
	Total	150 questions

There were five separate turret sections in the examination booklet, each one including twenty questions. Students selected one of these sections, according to their turret specialty. There was one general turret section, which all students took, also including twenty questions.

Sources and types of questions.—Many of the questions in GF–C were taken from GF–A. It was necessary to construct new questions for the specialized turret sections; and these were obtained mainly from other tests, from training manuals, and from instructors.

Almost half of the questions in GF–C were pictorial, about one-third were verbal, and the remaining one-sixth were diagrammatic. Most of the pictorial questions were included in the parts on weapons and aircraft recognition, although the part on sighting also included quite a few. The increased use of pictures in the test was due largely to a change of emphasis occurring in the training program. Nomenclature was no longer stressed in lesson plans; gunners were required to be able to work with their equipment, but were not required to be able to discuss it.

Statistical data.—Distribution constants and reliabilities for GF–C are presented in table 7.2. It can be seen from these data that the test had a fairly satisfactory reliability (0.79), and that there was considerable consistency in the mean scores as obtained from the different schools, and also from class to class within a school.

Table 7.3 states the intercorrelations of parts of the test, and the reliabilities and distribution constants of the parts and of the total test. All of these correlations are significant and positive.

[5] S/Sgt. Marvin Waldman was primarily responsible for supervising the development of this test.

TABLE 7.2.—*Reliabilities and distribution constants of GF–C total score in various classes at Harlingen and Laredo (October-November 1943)*

Class	School	N	M	SD	r[1]
43-39	Laredo	311	113.22	11.08	0.78
43-40	Laredo	379	116.09	9.95	.74
43-41	Laredo	401	111.01	11.14	.77
43-42	Harlingen	481	117.72	11.14	.80
	Laredo	402	111.25	10.78	.76
43-43	Harlingen	478	123.00	9.59	.76
	Laredo	446	114.93	10.78	.77
43-44	Harlingen	455	119.20	9.36	.72
	Laredo	393	112.27	11.15	.78
43-45	Harlingen	470	118.76	10.67	.78
	Laredo	436	113.10	11.57	.80
43-46	Harlingen	473	123.84	9.67	.77
	Laredo	430	117.84	9.86	.74
43-47	Laredo	431	118.00	11.04	.80
Total: 43-39 through 43-47	Laredo	3628	114.35	11.18	.78

[1] Reliabilities computed by Kuder-Richardson Formula No. 21. The number of items in GF-C is 156.

Form GF–D

Introduction.—Form D of the Final Comprehensive Examination was developed after GF–C had been in use in the gunnery schools about eight months. It was first administered in all the gunnery schools in April 1944. The most important difference between it and GF–C was that it emphasized even more the elements of recognition of essential features of equipment rather than verbalization about the equipment.[6]

Format.—GF–D consisted of the following parts and numbers of questions:

Part I.	Aircraft recognition	24 questions
Part II.	Sighting	29 questions
Part III.	Weapons	50 questions
Part IV.	Miscellaneous	7 questions
Part V.	Turrets (5 separate sections)	40 questions
	Total	150 questions

Part V of GF–D included one section of 10 questions applicable to all turrets, and separate sections for specific turrets, made up of 30 questions each.

Source and types of questions.—Sources for questions in GF–D were the same as for previous forms of the Final Comprehensive. Revisions were made necessary primarily because of the technical changes that had been made in equipment. More diagrammatic questions were used in this form than strictly verbal questions,

[6] Capt. Alfred C. Jensen, S/Sgt. Marvin Waldman, S/Sgt. Robert J. Ellingson, and Cpl. Walter Cohen were primarily responsible for the development of this test.

which was in accord with the decrease in emphasis on the gunner's ability to verbalize about his job.

Statistical data.—Table 7.4 presents the reliabilities of parts of GF–D and of the test as a whole. All coefficients were satisfactory with the exception of the one for the Bendix turret section. Table 7.5 indicates the consistency of the distribution constants and reliability coefficients as obtained from administration of the test to the various gunnery schools. The most reliable results were obtained for the weapons section.

TABLE 7.3.—*Intercorrelations, reliabilities and distribution constants of parts of GF–C, class 43–44, Las Vegas (N=509) and class 43–42, Buckingham (N=521, October 1943)*

Part	Number of items	Part 1	Part 2	Part 3	Part 4	M [1]	SD [1]	r [1]
1. Aircraft recognition	25							
Las Vegas			0.37	0.22	0.26	24.14	2.81	0.40
Buckingham			.40	.20	.28	23.71	2.91	.41
2. Sighting	25							
Las Vegas		0.37		.40	.31	37.66	3.55	.51
Buckingham		.40		.34	.38	36.61	3.69	.49
3. Weapons	50							
Las Vegas		.22	.40		.24	30.80	2.26	.27
Buckingham		.20	.34		.41	31.10	2.41	.40
4. Turrets	40							
Las Vegas		.26	.31	.24		34.39	3.76	.66
Buckingham		.28	.38	.41		33.74	2.84	.35
Total score	150							
Las Vegas						127.00	8.53	.73
Buckingham						125.10	8.55	.72

[1] Reliabilities and distribution constants based on 530 cases at Las Vegas and 518 cases at Buckingham. All reliabilities computed by Kuder-Richardson Formula No. 21, using all answer sheets from the classes indicated. Intercorrelations are based on answer sheets with no omits or nonreads.

Forms GF–E and GF–F

Introduction.—Three different examinations were developed in this series to meet the needs of the different training programs. All of these examinations were produced in two alternate forms. Form GF–F included the same questions as GF–E, but items were arranged in a different order.

The revision of the GF–D was made necessary by the many changes that had occurred in the locally controlled gunnery equipment and course content. Some of the schools having reported difficulties in administering GF–D in a 2-hour period, it was planned to include fewer questions in GF–E and GF–F and to set the testing time at 1 hour and 50 minutes. The use of both of these forms in the basic gunnery schools was initiated in Novem-

ber 1944, and continued until the close of the war in all of the B-17, B-24, B-25, and B-26 programs.[7]

TABLE 7.4.—*Reliabilities and distribution constants for GF-D total and part scores based on combined data from various gunnery schools (July-August 1944)*[1]

	N	Number of items	M	SD	r
Aircraft recognition	4,250	24	17.53	3.63	.67
Sighting	4,250	29	17.13	4.09	.60
Weapons	4,250	50	35.94	6.24	.76
Crewmanship	4,250	7	5.41	1.16	.10
Turrets:					
Bendix	250	40	28.51	3.18	.20
Consol. tail	500	40	34.29	4.29	.75
Martin upper	1,250	40	34.23	3.62	.64
Sperry ball	1,250	40	33.50	4.43	.74
Sperry upper	500	40	28.20	5.22	.71
Total	4,250	150	112.24	14.93	.87

[1] Data on reliabilities and distribution constants for parts of GF-D for each gunnery school are presented separately in table 7.5. All reliabilities computed by Kuder-Richardson Formula No. 21.

The use of the A-26 and B-29 aircraft demanded new gunnery training programs which differed considerably from all previous programs. Two new final comprehensive examinations were developed for these training programs. The A-26 examination was printed and distributed to Tyndall for use in February 1945, and the B-29 examination was distributed to Buckingham, Harlingen, and Las Vegas in May, 1945.[8] Both of these examinations were used until the close of the war.

Format.—GF-E and GF-F for B-17, B-24, B-25, and B-26 aircraft consisted of the following parts and numbers of questions:

Part I.	Sighting	30 questions
Part II.	Weapons	45 questions
Part III.	Crewmanship	30 questions
Part IV.	Turrets (7 separate sections)	30 questions
	Total	135 questions

[7] Capt. Lawrence M. Stolurow, Capt. Kenneth B. Henderson, Sgt. Herbert W. Goldstrom, Sgt. Paul Freeman, and Cpl. William C. Mooney were responsible for the development of this test.

[8] Capt. Lawrence M. Stolurow, Capt. Kenneth B. Henderson, Lt. John G. O'Hare, S/Sgt. Lea A. Carey, Sgt. Herbert W. Goldstrom, Sgt. Seymour Kern, and Cpl. William C. Mooney were responsible for the development of these tests.

TABLE 7.5.—*Reliabilities and distribution constants for GF–D part scores at various gunnery schools (July-August 1944)*[1]

	N	M	SD	r
Aircraft recognition (24 items):				
Buckingham	500	18.76	3.11	0.60
Harlingen	750	18.09	3.58	.68
Kingman	500	15.50	3.04	.42
Laredo	1,000	17.12	4.16	.75
Las Vegas	500	16.76	3.23	.54
Tyndall	500	17.93	3.32	.61
Yuma	500	18.69	2.92	.54
Sighting (29 items):				
Buckingham	500	19.13	3.46	.47
Harlingen	750	17.94	4.20	.65
Kingman	500	14.91	3.92	.55
Laredo	1,000	17.31	4.12	.61
Las Vegas	500	15.33	3.43	.40
Tyndall	500	17.37	3.92	.55
Yuma	500	17.28	3.56	.47
Weapons (50 items):				
Buckingham	500	38.06	5.73	.74
Harlingen	750	37.34	5.90	.74
Kingman	500	32.83	5.93	.69
Laredo	1,000	36.57	6.39	.78
Las Vegas	500	37.04	6.03	.78
Tyndall	500	33.62	6.01	.71
Yuma	500	34.78	5.07	.69
Martin turret (40 items):				
Buckingham	250	34.12	2.51	.21
Harlingen	250	35.18	4.73	.83
Laredo	250	34.55	3.18	.55
Tyndall	250	33.59	2.66	.61
Yuma	250	33.72	3.32	.53
Bendix turret (40 items):				
Buckingham	250	28.51	3.18	.20
Consolidated (40 items):				
Harlingen	250	35.56	2.95	.56
Laredo	250	33.03	4.50	.78
Sperry upper turret (40 items):				
Harlingen	250	35.02	3.47	.65
Kingman	250	31.77	5.07	.77
Laredo	250	33.42	3.71	.62
Las Vegas	250	34.12	3.78	.61
Tyndall	250	33.19	3.24	.47
Sperry lower turret (40 items):				
Kingman	250	26.24	5.37	.71
Las Vegas	250	29.28	4.05	.47
Yuma	250	30.16	4.24	.60

[1] All reliabilities computed by Kuder-Richardson Formula No. 21.

GF–E and GF–F for A–26 aircraft consisted of the following parts and numbers of questions:

Part I.	Weapons	45 questions
Part II.	Aerial gunnery problems and sighting station	40 questions
Part III.	Emergency procedures and equipment	15 questions
Part IV.	Turrets	35 questions
	Total	135 questions

GF–E and GF–F for B–29 aircraft consisted of the following parts and numbers of questions:

Part I.	Weapons	45 questions
Part II.	Emergency procedures and interphone	30 questions
Part III.	Aerial gunnery problems	30 questions

Part IV. Sighting stations (4 separate sections) ...... 45 questions
General questions 20
Specific questions 25
Total .... 150 questions

Source and type of questions.—The sources and types of questions for all of the GF–E and GF–F examinations were approximately the same as for previous forms. Use was made of many of the pictures in the Gunners Information File, which had become an established textbook in the gunnery schools.

Statistical data.—An experimental form of the GF–E for the locally controlled turret gunners, designated GF–EE, was first prepared and administered at six of the gunnery schools for the purpose of obtaining data on the basis of which refinements could be made to many of the new questions. Data obtained in the administration of this form of the test are presented in table 7.6.

TABLE 7.6.—*Estimates of the reliability of the parts and total scores of the experimental edition of the final comprehensive examination (form GF–EE, six schools, September-October 1944)*[1]

Part	Number of items	N	Part r	Total r[2]
Aircraft recognition	15	1,756	0.71	
Sighting	30	1,756	.57	
Weapons	45	1,756	.76	
Crewmanship	30	1,756	.50	
Bendix chin turret	30	[3] 325	.27	0.67
Bendix upper turret	30	[3] 50	.28	.70
Emerson nose turret	30	[3] 250	.86	.90
Martin turret	30	[3] 300	.84	.89
Motor products turret	30	[3] 250	.85	.90
Sperry ball turret	30	[3] 550	.82	.86
Sperry upper turret	30	[3] 325	.75	.86

[1] Kuder-Richardson Formula No. 21 used.

[2] Total score for each gunner included scores on aircraft recognition, sighting, weapons, crewmanship, and one of the turret sections.

[3] These N's are estimated on the basis of proportions of students studying each type of turret.

Data obtained from administration of GF–E and GF–F, for locally controlled turrets, as finally constructed are presented in table 7.7. Distribution constants and reliabilities for the B–29 version are presented in table 7.8.

Summary

The Final Comprehensive Examination went through four revisions, all of which were necessitated by changes in the curriculum, the equipment, and by statistical considerations of test reliability, item difficulty, and item discriminations. The changes

TABLE 7.7.—*Intercorrelations of sighting, weapons, crewmanship and total scores with all part scores on GF–E and GF–F, and reliabilities of part and total scores, all schools (March–May 1945)*

Parts[1]	Test	N	Parts 1	Parts 2	Parts 3	Total	M	SD	r[2]
1. Sighting	GF–E	1,121	--------	0.60	0.46	0.80	17.84	4.90	0.72
	GF–F	960	--------	.54	.43	[3].81	17.63	4.31	.71
2. Weapons	GF–E	1,121	.60	.54	.54	.88	31.98	6.58	.80
	GF–F	960	.54	--------	.45	[3].86	32.72	5.86	.76
3. Crewmanship	GF–E	1,121	.46	.54	--------	.72	21.62	3.44	.51
	GF–F	960	.43	.45	--------	[3].69	20.80	3.26	.42
4. Emerson nose Turret	GF–E	126	.69	.60	.59	.82	21.18	3.62	.54
	GF–F	137	.62	.54	.39	.77	21.75	3.54	.51
5. Motor products Tail-turret	GF–E	126	.44	.37	.34	.69	21.00	5.32	.80
	GF–F	130	.58	.51	.38	.75	22.66	3.78	.63
6. Bendix Chin turret	GF–E	239	.42	.51	.36	.72	21.33	3.01	.33
	GF–F	51	.59	.50	.47	.81	19.31	4.62	.70
7. Sperry Upper turret	GF–E	149	.37	.43	.28	.66	23.16	3.39	.56
	GF–F	51	.48	.36	.38	.66	21.00	3.00	.31
8. Sperry ball (Retractable)	GF–E	77	.47	.62	.49	.81	20.22	4.80	.74
	GF–F	90	.56	.66	.39	.82	19.79	4.00	.60
9. Sperry Ball (Non-retract.)	GF–E	150	.45	.53	.47	.75	20.05	3.69	.53
	GF–F	50	.48	.42	.43	.71	20.72	3.46	.47
10. Martin Upper turret	GF–E	183	.32	.45	.25	.67	22.88	3.38	.54
	GF–F	218	.40	.39	.26	.70	22.30	3.41	.53
11. Total Score	GF–E	1,121	.80	.88	.72	--------	93.27	15.20	.88
	GF–F	822	.81	.86	.69	--------	93.50	14.37	.87

[1] All parts consisted of 30 items each, except weapons which consisted of 45 items; total test consisted of 135 items.

[2] Reliabilities computed by Kuder-Richardson Formula No. 21.

[3] Correlations of GF–F total scores with Sighting, Weapons, and Crewmanship based on 822 cases.

in emphasis in training which occurred are reflected in the relative number of pictorial, diagrammatic, and verbal items that are used in the different forms of the test (see table 7.9) and in the specific material covered by the examination questions. The different forms of the Final Comprehensive Examination were all reliable

Table 7.8.—*Distribution constants and estimates of reliability of parts of B-29 edition of GF-E (Buckingham, July 1945)*

Part	Number of items	N	M	SD	r[1]
Weapons	.45	431	34.94	5.47	0.76
Emergency procedure and interphone	.30	400	23.96	2.50	.22
Gunnery problems	.30	400	24.77	3.06	.56
Turret-blister	.45	200	37.15	3.79	.56
Turret-tail	.45	100	35.78	3.64	.46
Turret-ring	.45	100	40.23	2.99	.54
Turret-nose	.45	100	38.38	3.27	.48

[1] Kuder-Richardson Formula No. 21.

enough to provide relatively stable measures of performance in gunnery school. They served as the most important determiners of graduation and elimination. The establishment of a Final Comprehensive Examination which was standard in all schools was considered to have done much to improve training and to increase its consistency from school to school and from class to class.

Table 7.9.—*Types of items and number used in each part of each form of the flexible gunnery school final comprehensive examination*

	Form of test			
	GF-A items	GF-C items	GF-D items	GF-E & F items
Aircraft recognition:				
Pictorial	30	12	20	
Diagrammatic	0	1	4	
Verbal	0	12	0	
Total	30	25	24	
Sighting:				
Pictorial	8	12	11	25
Diagrammatic	5	8	9	0
Verbal	32	5	9	5
Total	45	25	29	30
Weapons:				
Pictorial	0	47	38	33
Diagrammatic	0	0	2	1
Verbal	45	3	10	11
Total	45	50	50	45
Miscellaneous:				
Pictorial		0	0	
Diagrammatic		0	0	
Verbal		10	7	
Total		10	7	
Crewmanship:				
Pictorial				2
Diagrammatic				0
Verbal				28
Total				30

TABLE 7.9.—*Types of items and number used in each part of each form of the flexible gunnery school final comprehensive examination*—continued

	Form of test			
	GF–A items	GF–C items	GF–D items	GF–E & F items
Turrets:				
Pictorial	0	0	0	[1] 14
Diagrammatic	0	19	30	0
Verbal	30	21	10	[1] 16
Total	30	40	40	30
Total:				
Pictorial	38	71	69	74
Diagrammatic	5	28	45	1
Verbal	107	51	36	60
	150	150	150	135

[1] This is an average value based on seven different turret sections.

CHAPTER EIGHT

The Development and Use of Phase Checks

Capt. JOHN A. VALENTINE[1]

INTRODUCTION

Nature of Phase Checks

The phase checks used in the flexible gunnery program represented a type of performance test that was found to be effective in training and testing gunners on the care and use of their equipment. Although phase checks had some precedent in the history of performance testing, their format and the procedures for their administration and scoring developed as the result of a series of specific solutions to immediate, practical testing and training problems in gunnery.

Origin of phase checks.—Phase checks grew out of a need for a dependable test of the gunner's ability to operate and care for his equipment. The ultimate responsibility of every gunner was to be able to aim and shoot effectively at attacking enemy fighter planes, but the bulk of his work, in terms of time and energy consumed, consisted of maintaining and readying for use the complex tools of his trade—his guns, sight, and turret.

Written tests were prepared early in the program which measured with satisfactory accuracy how much the gunner knew about his equipment (see chapter 7). The disturbing problem was that it was not so important for the gunner to "know" things about his equipment as to be able to "do" things with it. There was no guarantee that the individuals who scored high on a writ-

[1] Phase checks were developed by a group of officers and enlisted men working over a period of three years. Those chiefly responsible were Capt. Lawrence M. Stolurow, Capt. John A. Valentine, Capt. Wilbur S. Gregory, Lt. Gerald R. Pascal, Lt. John G. O'Hara, T/Sgt. Robert W. Rech, S/Sgt. Robert Ellington, S/Sgt. Robert G. Bainbridge, S/Sgt. Lee A. Carey, S/Sgt. Marvin Waldman, Sgt. Cyril A. Bahl, Sgt. Jack T. Huber, Sgt. Seymour Kern, Cpl. Philip M. Brown, Cpl. Robert H. Hubbell, Cpl. John H. Lickteig, Cpl. William C. Mooney, and Pfc. Robert Wilinski. Technical assistance was given by a number of gunnery experts.

ten examination on the caliber .50 machine gun could strip and assemble or make adjustments on the weapon with greater competence than those who scored low. What was called for was a test of doing, rather than of knowing.

The first attempts at a test of doing consisted of recording a list of steps required of the gunner in the performance of some limited aspect of his job. He would then be asked to do this part of the job, while the instructor stood by attentively, marking him either right or wrong on each step. A score was obtained by totaling the number of steps on which the gunner was marked wrong. Early forms of the phase checks on stripping and assembly of the caliber .50 machine gun consisted of just such simple lists of steps.

Later modification of phase checks.—Phase checks were originally conceived as measuring proficiency in one of the successive phases of gunnery training. As a student completed a certain part of his instruction, for example on the loading of ammunition into his turret, he would be given a "check" on that "phase" alone. The name "phase check" was thus a literal description of the instrument's function as used at that time. Gradually, however, the checks embraced more of the gunner's job. This tendency was in accord with the growing emphasis on training gunners to see the whole nature of their job, rather than on giving them instruction and practice in a variety of specific skills and duties and expecting them to grasp the over-all implications. In the closing months of the war some phase checks included all procedures pertinent to the care and use of equipment, and were so organized for administration as to simulate closely the sequence of activities, other than actual aiming and firing, engaged in before, during, and after a combat mission. An effort was made to rename these later tests "proficiency checks," but the phrases "phase check," "phase checker," and "phase checking," were by then an accepted part of gunnery vocabulary and remained so. Originally denoting simple, periodic checks of the gunner's ability to master phases of his training, phase checks eventually became extensive measures of his over-all proficiency in maintaining his equipment and preparing it for combat use.

The dual function of phase checks.—From the first days of phase checking it was recognized that these instruments which were so effective in testing what gunners could do with their equipment were also useful in training gunners. In requiring students to perform each step of a total job in the correct manner, phase checks provided the best possible application of the "learn by doing" principle, and therefore formed a basis for all ground training in the care and preparation of gunnery equipment.

Example of a Phase Check

In order to make the discussion that follows more meaningful to the reader, the following section from the most widely used flexible gunnery phase check, that on the stripping and assembly of the caliber .50 machine gun, is reproduced here. Reading these brief instructions to the phase checker, and the items that follow, will clarify such phrases as phase check "step," "error," "performance," and "procedure," which occur frequently in the chapter.

Field strip and assembly.—Fill in, or have the gunner fill in, his name, [illegible], weapons instructor, the date, etc., in the appropriate spaces on the Score Sheet. Blindfold the gunner and check to see that the blindfold is secure and the gunner can see nothing. Then help him put on his winter flying gloves. Observe the gunner to see if he is unusually nervous or ill-at-ease. Do anything possible to put him at ease before starting him on the phase check. Tell the gunner: "field strip your gun. No adjustments will be necessary." As he starts, put down the exact time he begins in the space provided for that purpose on the Score Sheet. Watch to see that he:

(1) Raises cover and checks feedway.
(2) Charges gun twice properly, making sure cover is closed. (Mark an error if cover is left up.)
(3) Makes sure parts are in battery position before removing backplate.
(4) Removes the backplate. (Mark an error if he fails to remove the driving spring rod assembly completely from the bolt group before removing the bolt group.)
(5) Removes the bolt stud, and removes the bolt group.
(6) Rotates cocking lever to the rear. (Mark an error if he depresses sear before doing this.)
(7) Releases the firing pin by depressing the sear.
(8) Depresses oil buffer body spring lock. (Mark an error if he pulls on oil buffer group before doing this.)
(9) Pulls out the oil buffer and barrel groups part way.
(10) Separates oil buffer and barrel groups.
(11) Removes barrel group from casing.[3]

PROCEDURES FOLLOWED IN THE DEVELOPMENT OF PHASE CHECKS

During the months of construction of flexible gunnery phase checks, a body of knowledge was gradually accumulated which served to expedite the construction of each successive check.

[3] Standardized Phase Check, Stripping and Assembly of the caliber .50 machine gun, form B. November 1944, page 1. This phase check is reproduced in full in appendix C, together with a list of all flexible gunnery phase checks prepared by the Central School.

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Some of this knowledge concerned the preparation, and some of the scoring and use of phase checks. This section of the chapter will be concerned with briefly describing some of the more important things that were learned about these areas. An attempt will be made to stress the points that may have a profitable bearing on the application of phase check procedures to types of behavior other than that involved in flexible gunnery.

Initial Considerations

Before attempting construction of a phase check, it was necessary to ensure that the behavior under consideration was scorable by phase check methods. This was ascertained by asking three questions: (a) was the method of behavior standard, so that all students could be expected to perform the same steps in the same way and in the same order, (b) was the behavior itself observable, and, (c) in cases where the behavior was not observable, was it possible to score the product or outcome of the behavior?

Standard method of behavior.—The problem of variability in method of behavior proved to be troublesome in the early days of phase checking. Students at different schools often learned different ways of performing certain steps, whereas a phase check could only be administered fairly to the students who had learned the same steps that were included in the check. This problem of nonstandard behavior was solved by the use of phase checks as bases for instruction. Because the phase check included all of the steps that the student had to learn in order to master a particular area of his job, there was no reason for withholding the check from him until he took it as a test. Indeed, there was good reason for letting him study and practice the steps as much as he wished, because in preparing himself to take a phase check he was directly preparing himself for his combat duties. The use of phase check practice in the classroom was therefore encouraged, and provisions were made to give each student phase check material to study on his own.

Observability of behavior.—In planning a phase check, it was found that attention became so concentrated on the behavior sequence under consideration that the examination function of the phase check was often overlooked. The gunner's behavior was most often obscured by the locale of the operation (e.g., the inside of a turret), and by the gunner himself (e.g., during certain fine manipulations of parts of the machine gun). It was necessary to allow for the presence of an observer wherever possible; otherwise an undue proportion of the phase check would consist of usually inadequate inspections of the outcome of the gunner's work.

Scorability of behavior outcome.—In cases where it was necessary to score the outcome of the gunner's work, either because the behavior was not directly observable, or because simply watching the behavior was not sufficient for indicating its correctness, the problem was one of finding the most complete and sure check of correctness. This usually involved having the phase checker inspect one completed step to see whether it had produced the correct result.

Preparation of Phase Check Items

Once it was determined that a phase check was feasible, on the basis of the above considerations, it was possible to start constructing the work form of the phase check. The basic unit of any phase check was the items. Items were prepared with the following points in mind: their wording; their discreteness; their scoring; their order; and their closeness to actual combat conditions.

Wording.—It was found that unless the wording of each item was accurate, complete, and detailed, confusion would arise at times as to its meaning and correct scoring. An example will serve to illustrate this point. In most of the turret phase checks, one step consisted of checking the gun mounts for security. It was not sufficient, however, to state simply "check gun mounts for security;" it was necessary to include as much information as possible on how this was to be done: "he should try to rock guns in their cradles, and check front and rear studs and mounting bolts." The item was still not a very satisfactory one; there was too much room for variation in the interpretation of the words "try" and "check." The item was possibly a source of unreliable administration,[3] but it had become approximately as accurate as words and space permitted. For some steps, there might be one likely and frequent student error that was profitably pointed out in the wording of the item. For example, the simple item "enters turret" was improved by the qualifying parenthesized phrase "if he grasps sight cradle or rods, mark an error."

In preparing most items, the problem was primarily one of clarity of expression. Effort was directed toward making the greatest amount of sense while using the smallest number of words. In general, each item was worded so as to tell the phase checker quickly what the gunner was supposed to be doing, and, where necessary, what exactly constituted correct and incorrect performance.

Discreteness.—As the student was scored either right or wrong

[3] See page 129 of this chapter for a brief discussion of phase check reliability.

on each item, it was important that the item included only one distinct step of behavior. A good test of discreteness was found to be inquiring if you would know what you wanted to know about the student's performance in case he was marked an error on a certain item. Making items discrete considerably increased the training value of the phase check by specifically indicating to the gunner his particular errors.

It was possible to carry this objective of discreteness to absurd limits. Practically any unit of human behavior may be subdivided into smaller units, progressing from a teleological description of the behavior to a literal description of what various bodily groups and members do during their behavior. It was essential that perspective be maintained regarding the significance of each item. It was found helpful to keep in mind the fact that the phase checker was going to be required to observe, evaluate, and score every item recorded in the phase check, and that he was going to be working within definite time limits.

Scoring.—For scoring purposes, the description of the step itself was in most cases enough, and the phase checker was able to determine from simply observing the student's behavior whether or not the step was being performed correctly. In a few cases, as mentioned above, observation of the behavior was not sufficient for scoring purposes, and some check was required of the product or outcome of behavior.

Attempts were made in some early forms of the phase checks to provide for an error being scored in the event that a student "started" to do a wrong thing, or, "tried" to do a wrong thing. Such scoring procedures were unsuccessful for two reasons. They demanded of the phase checker judgments that were too difficult, and they did not allow for the fact that what often seemed to be a gesture in the direction of a wrong performance might be a nervous, superfluous movement. In general, the phase checker was not required to make any judgments beyond determining whether the subject did a specific thing or did not do it.

Order.—In considering the order in which separate steps were to be performed during the phase check, it was necessary to take into account two factors: how significant a role order played in the behavior, and, how order might best be included in the scoring of the behavior. The following examples from flexible gunnery phase checks suggest the methods that were used for scoring order.

Example A:

Item 1. "Turns on master power switch. (If he turns on any other switch first, mark an error.)"

Example B:

Item 1. "Turns on main power circuit breaker."
Item 2. "Turns on sight circuit breaker."
Item 3. "Turns on sight switch. (If he fails to turn on main power circuit breaker *and* sight circuit breaker before turning on sight switch, mark an error.)"

Example C:

Item 1. "Removes oil buffer tube. (Mark an error if he removes either the tube lock or accelerator before doing this.)"
Item 2. "Removes oil buffer tube lock. (Mark an error if he removes accelerator before doing this.)"
Item 3. "Removes the accelerator."

When it was desired that groups of steps be performed in a certain order, although no order of steps was demanded within groups, some such statement as the following was included in the necessarily or logically first item of each group; "mark an error if he starts work on another group first." If no specific order was required of the student, it was well to state this fact emphatically in the directions to the phase checker; otherwise the fact that items were listed in a certain order in the phase check would imply that the particular order used was demanded.

Simulation of actual combat conditions.—As much as possible, phase check items were so prepared as to require the student to do the "real" thing. For example, if he was demonstrating how to load ammunition into a turret, he was required actually to load real ammunition in a real turret. If this principle of realness was not adhered to, the phase check situation tended to impose its own limited significance on items. There was also danger of making the phase check either harder or easier than the actual job. For a long time gunners learned to detail strip and assemble the machine gun wearing blindfolds. This procedure was dictated partly by combat experience, in that gunners were actually required to work on their guns in the dark at some advanced Pacific air fields. It was also judged, however, that by learning to do the task under the handicap of a blindfold the gunner would gain greater proficiency in doing the task without a blindfold than he would if he learned without such a handicap. An occasion arose to phase check some gunners without blindfolds who had been trained to work with blindfolds, and it was reported that their errors increased. No formal analysis was made of the data. Apparently the cues used with effectiveness when the gunners wore blindfolds lost some of their effectiveness when the gunners could see.

Summary.—The following questions were profitably asked concerning phase check items:

(1) Did each item accurately, thoroughly, and clearly describe the behavior with which it was concerned?
(2) Did each item contain only one significant step of behavior?

(3) Was the scorability of each item taken into account?
(4) Was the scoring of order of steps taken into account, and was allowance made for variation in order where applicable?
(5) Did each item impose essentially the same significance on the step that it would have in the job itself?

Having prepared a set of items that met the above requirements, they were given to several qualified individuals for review and criticism. This procedure usually produced a number of corrections and valuable suggestions for improvement. In the case of behavior involving equipment, it was especially important that items be reviewed and tried out to make sure that the use of the equipment was correctly described. For this purpose the aid of a technical expert on the equipment was necessary.

Preparation of Directions

Directions for phase checkers.—After all of the phase check items were prepared in preliminary form, and organized into the most appropriate and efficient groups, it was necessary to prepare directions for the administration of the phase check. Typical directions will be found in the phase check on stripping and assembly of the caliber .50 machine gun included in Appendix C. Directions always specified exactly the conditions for administernig and scoring of the check.

Directions to be read to student.—In preparing the directions that the phase checker read to the student, four major points were kept in mind: they were made to sound like the phase checker, in terms of vocabulary and form of expression; they were written so as to be clear to the students (the word "deviations" was found to have baffled numerous gunnery students); they covered exactly what the student was expected to do; and they contained just as much information as a student could readily grasp at one time.

Scoring of Phase Checks

Problems in the scoring of phase checks centered around five topics: the scoring of items, the weighting of items, converting to part scores, converting to final scores, and scoring for speed as well as for accuracy.

Scoring of items.—It was decided that each item on a phase check would be scored on an all-or-none basis. That is, a student was considered as having performed a step either correctly or incorrectly. The nature of a phase check item, in describing one integral step of behavior, made this type of dichotomous scoring most desirable. An additional argument for such scoring came from the fact that a phase checker would usually be hard pressed

to make even dichotomous judgments about items when observing a rapidly moving sequence of performance.

Weighting of items.—The problem of weighting phase check items arose soon after phase checks came into being. Although in a sense all phase check items were important, because each one played an essential role in the total performance, it was judged that items might also vary among themselves in significance. The first attempts to assign weights to items were based on the opinions of several qualified gunnery authorities, who selected the items they felt to be most crucial in each phase check. The criterion that they most frequently used was that the equipment would not operate in the gunner made an error on a certain item. A rather severe scoring procedure was adopted for these crucial, or "major" items, as they were called; a student was considered to have failed an entire phase check if he made an error on one such item. Criticism of this scoring system soon came from a variety of sources, aimed not so much at the system itself as at the choice of items to be considered as crucial. Conferences were called in which an attempt was made to pin the discussion down to certain arbitrary assumptions regarding crucial items. It was found, however, that there were about as many opinions regarding the relative significance of items as there were gunnery authorities. The use of major items was discontinued for the time being, and attempts were made to determine the significance of items on bases other than personal opinion.

Combat records of gunnery equipment failures were studied in the hope of arriving at certain common malfunctions of equipment which related to specific items on the phase checks. Data of this sort varied considerably, however. There was apparently little consistency in the type of mistakes that gunners made in preparing their equipment for combat use.

The number of times that students were scored as being in error on certain items was considered as a possible criterion for assignment of weights, in that such data tended to indicate the relative difficulty of mastering these items. Including the factor of relative item difficulty in the scoring would have enabled the student to get extra credit for mastering the more difficult items. It was found, however, that such data varied from school to school and even from instructor to instructor, reflecting differences in emphasis and quality of training received by the students prior to taking the phase checks.

The decision was finally made to dispense with any system of weighting and to consider all items on an equal basis.

Converting to part scores.—Most of the phase checks were or-

ganized conveniently into parts, each part relating to a distinct aspect of the gunner's job. It was desirable to have a separate converted score for each part in order to point up for both the instructor and student possible areas of weakness. Scoring tables were constructed, therefore, which enabled the error scores of students on each part to be converted to scores on a five-point scale. Ideally, a score of 5 would represent the top 4 percent of the population, a score of 4 would represent the next 24 percent, a score of 3 the middle 44 percent, a score of 2 the next 24 percent, and a score of 1 the lowest 4 percent. Scoring tables were derived wherever possible from the results of administering the phase checks to properly selected groups. In many cases, however, due to the practical and immediate necessity of supplying the using schools with scoring tables for a new phase check, they were constructed on an *a priori* basis, and later revised.

Converting to final scores.—Once standard scores had been determined for each part of a phase check, it was necessary to devise some system for converting these separate standard scores to a final standard score. This was done by totaling the standard scores for all parts, and then converting the total to a five-point scale on the basis of a table designed to yield approximately the same percentages in each category as are indicated above for part scores.

Scoring of time.—For some types of gunnery performance, speed was of importance and was taken into account in the scoring of the phase checks concerned with such performance. For these phase checks, time data as well as error data were considered in preparing tables for converting scores to standard scores. The most careful judgments possible were made in such cases by members of the psychological tests section regarding the relative importance of time and errors. For phase checks including time as a factor of performance, the student's standard score was determined by joint reference both to columns of time limits and of error limits. A time-error scoring table is included in the phase check on stripping and assembly of the caliber .50 machine gun reproduced in appendix C.

Changes in scoring emphasis during war.—During the early period of flexible gunnery training, when phase checks first came into use, they were used primarily as tests of proficiency in the Training Command basic gunnery schools. They had only a limited use as training aids, and students did not take them more than one or two times as tests. Consequently, there was usually a sizable range of errors made on the phase checks. Most other scores of proficiency at that time were converted to a five-point

scale, and as the range of errors made such a scoring system feasible for phase checks, phase check error scores were also converted to a five-point scale as discussed above. As the use of phase checks in the gunnery program grew, however, the scoring situation changed. Due to the fact that students were eventually given opportunities to practice many times on each phase check, as well as to take each phase check several times as a test, the range of errors made decreased to a very small number. In this later period, when such conditions obtained, it often became impracticable to divide students into more than two categories of success and failure. Scores were eventually used as evidence of mastery of gunnery tasks, and as indications of areas of weakness on the part of students.

The Validity and Reliability of Phase Checks

Validity of phase checks.—On logical grounds, the validity of phase checks was inherent in their nature, as in most cases the student was required to do the same things that he would eventually have to do in combat. The conditions under which he worked were, of course, never simulated completely, but it was reasonable to suppose, due to the technical and stereotyped nature of the behavior, that students who demonstrated that they knew how to perform a step on the phase check would probably be able to perform the same step under other circumstances.

Reliability of phase checks.—Two differences between phase checks and other types of tests influenced consideration of the reliability of phase check scores. First, a phase check always included all of the steps involved in a certain performance. The application of sampling procedures was ruled out, because of the dual role of phase checks as training aids as well as testing devices. Each item earned its right to be in the phase check due to the fact that it served a purpose in the total performance. This fact also ruled out the possibility of constructing alternate forms of any phase check. Second, phase checks included several sources of possible influence on scores, other than student performance. Scoring of phase checks was influenced by the phase check items, by the phase checker's observations and judgments, and by the type and condition of the equipment used in the phase check, as well as by the student's performance.

In an early study the reliability of scores on the phase check on stripping and assembly of the caliber 50 machine gun was estimated to be 0.65 (Kuder-Richardson Formula No. 21). That reliability as measured by traditional methods would be low was ensured by the fact that a large proportion of phase check items had approximately a zero degree of difficu[illegible]. Further it was im-

possible to effect the revisions of the phase checks that these measures of reliability suggested. It was impossible, for example, to eliminate items of zero and near-zero difficulty, on the basis of considerations discussed above, and it was inadvisable to group items together, because of the desirability of using scores diagnostically.

The revision of phase check items to improve clarity of expression, discreteness, and scorability was felt to be the most effective means of increasing reliability.

Two other factors in the phase checking situation, the phase checker and the equipment, were sources of unreliability. Attention was consequently paid to reducing the scoring variability caused by these two factors. Although no formal study was made of the reliability of phase-checkers' judgments, it was recognized that phase checkers often differed in their judgments of performance on items. This was due to such factors as relative accuracy of observations and relative expression of leniency. Constant attempts were made to indoctrinate phase checkers with the necessity of administering and scoring every phase check in the same way. This was the primary objective of the phase check course in the Instructors School. A manual and a training film for phase checkers were also developed and used to teach proper procedure.

Variability in equipment also led to variability in scoring, although it was difficult to isolate this factor from all the other factors involved in a student's performance. Attempts were made to ensure that the right equipment, in good condition, was always used in phase checks.

DESCRIPTION OF FLEXIBLE GUNNERY PHASE CHECKS

Flexible gunnery phase checks were first mimeographed in limited quantities for distribution to the seven basic gunnery schools in the Training Command. The purpose of the distribution was partly to supply the schools with standardized phase checks for their use in training and testing and partly to secure criticisms and suggestions for revision of the checks. As the use of the checks became more widespread, a considerable quantity of phase check booklets and score sheets was demanded not only in the AAF Training Command but also in the training air forces and combat air forces. A system was therefore adopted whereby the materials were prepared for publication in the Central School and the publication and distribution were accomplished by AAF Training Aids Division. This system had the advantage of making available the required quantities of phase checks, printed in durable and convenient form.

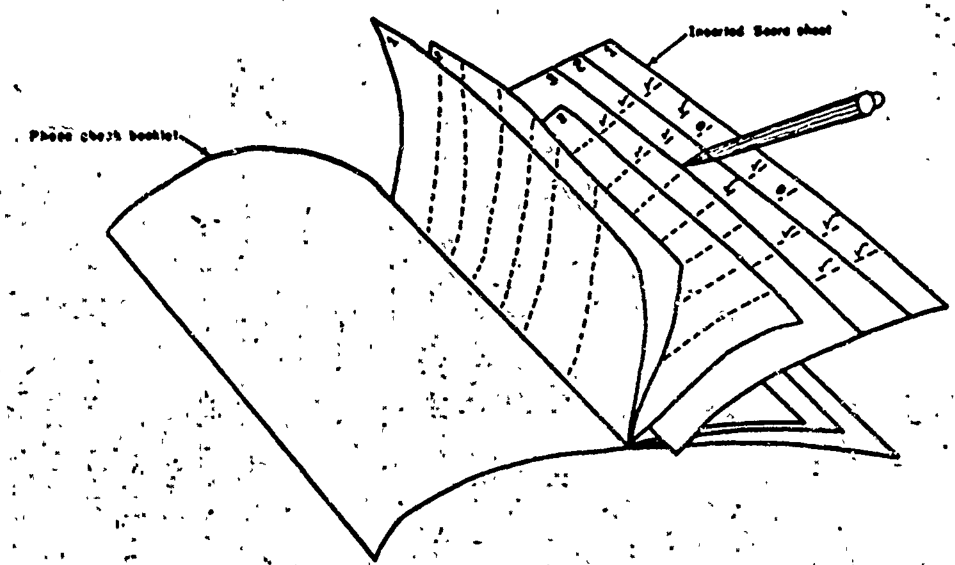

Fig. 8.1—ILLUSTRATION OF USE OF CUT-BACK PAGES IN FLEXIBLE GUNNERY PHASE CHECK FOR PURPOSE OF MAKING SCORING MORE CONVENIENT

Most of the phase checks were printed with pages successively cut back, so that when the student's score sheet was inserted at the proper place in the phase check booklet the phase checker was able to record a score (either a check mark or a zero) in a space on the score sheet immediately adjoining a description of each item. This system is illustrated in figure 8.1. It had the advantage of allowing the phase checker to refer conveniently to item descriptions while observing and scoring the student's performance. This was especially helpful to phase checkers with limited experience in phase checking. More experienced phase checkers memorized item descriptions and required the phase check booklets only for the reading of directions to the students.

The phase checks of the caliber .50 machine gun included items on taking the gun apart and putting it together, cleaning and oiling it, removing burrs from parts, and making adjustments. Each turret phase check consisted of items on basic operation, the loading of ammunition, the harmonization of the guns and sight, the making of a preflight inspection, and on procedures for getting in and out of the turret. The phase checks known as aerial proficiency checks covered all gunner activities concerned with a combat mission, including a briefing, personal equipment check, gun installation and preflight check, loading of ammunition, ditching procedure, emergency equipment check, intercom check, entering and manipulation of turret, air-to-air and air-to-ground firing, gun stripping, first aid, bail out procedure, and interrogation.

USE OF PHASE CHECKS IN THE FLEXIBLE GUNNERY PROGRAM

Use of Phase Checks as Tests

Use in basic gunnery schools.—With the publication and distribution of the first standardized series of phase checks in the spring of 1944, phase check scores were used as one basis for graduation or elimination in basic gunnery schools. Their use as a means of establishing minimum proficiency requirements was subsequently directed by Headquarters, Army Air Forces.[4] The following basic principles were adopted for the use of phase checks in Training Command schools:

(1) Each gunnery student was required to demonstrate his proficiency on all existing phase checks appropriate to the gun position for which he was being trained.
(2) The index of the student's proficiency was the final converted score received. A converted score of two (2) was the minimum passing score for each phase check.
(3) A converted score of one (1) indicated failure on any phase check.
(4) Any student failing to obtain a minimum passing score on the last regularly scheduled phase check was considered for elimination.

[4] AAF Training Standard 90-011, 21 June 1945, paragraph 4, page 3.

It also became standard operating procedure at most gunnery schools in the Training Command to include phase check score sheets among the other records considered by elimination boards when reviewing individual cases.

Use in training and combat air forces.—The use of phase checks as tests of proficiency gradually extended to the training air forces and finally to the combat air forces. The repute in which they were held by Headquarters, Army Air Forces, is evidenced by the following excerpts from an official AAF Letter, distributed to the commanding generals of all air forces:

> 5. It will be the responsibility of local commanders to insure that equipment required for the administration of Standardized Phase Checks is procured and maintained, that conditions for phase checking as specified in the Standardized Phase Checks . . . are adhered to, and that the individuals administering the Standardized Phase Checks are adequately trained and in sufficient numbers.
>
> 6. Air inspectors will make frequent and thorough inspection of all flexible gunnery training activities to insure that the Standardized Phase Checks are administered in accordance with the instructions contained therein . . .[3]

Results of testing with phase checks.—As an indication of the type of distributions of phase check scores obtained under normal operating conditions upon final administration at schools in the Training Command, figure 8.2 is presented. The students whose scores are included in this figure had already taken each phase check at least twice as practice. Study of the error scores of the three phase checks concerned in the figure reveals several points of interest regarding phase check scoring.

For one thing, it will be noted that the plottings of the frequency with which certain error scores are obtained create a skewed curve. The bulk of the students make from no errors to three errors, with successively fewer students making up to as many as 12 errors on one phase check (Martin turret). The ranges of errors are notably small, the greatest range being from 0 to 12. This smallness of range is appreciated when one considers the total number of items making up each phase check. In table 8.1, the mean number of errors, the range of errors, and the total number of items are presented for each phase check. The

TABLE 8.1.—*Mean errors and range of errors on phase checks of students at Laredo Army Air Field, with total items for each phase check (Class 45–35, August 1945)*

Phase check	N	Mean number errors	Range of errors	Total number items
Care and cleaning	107	2.68	0 to 12	75
Stripping and assembly	107	2.19	0 to 6	118
Martin turret	107	2.58	0 to 9	148

[3] AAF Letter 50-79, Headquarters, Army Air Forces, 11 December 1944, page 2, paragraphs 5 and 6.

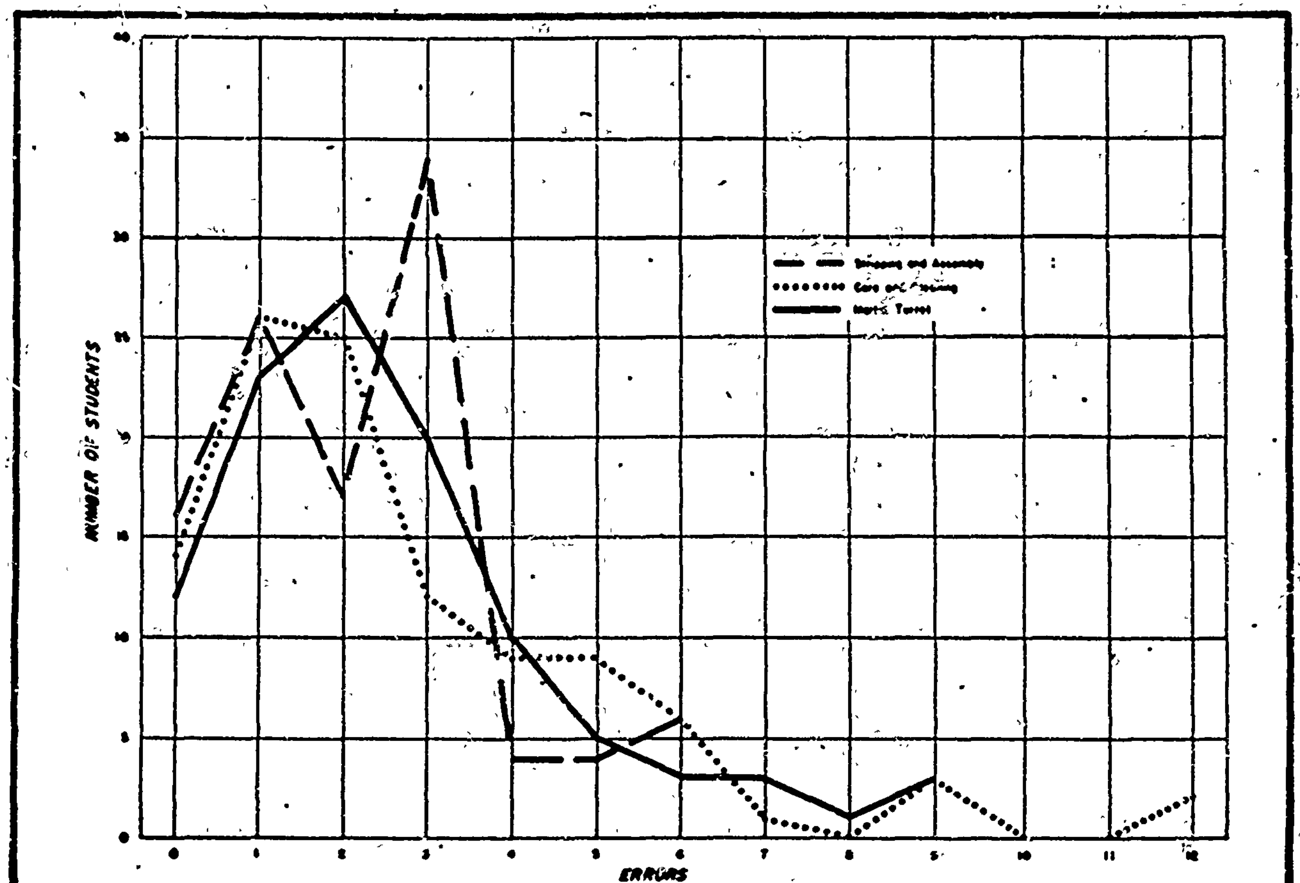

Fig. 8.2 — Typical distributions of error scores on phase checks: errors made on three final phase checks by Martin turret gunners (N=107, Class 45-33, Laredo, Aug. '45)

average number of errors on the Martin turret check is 2.58, with the poorest student making 9 errors, out of a total of 143 possible errors.

During their training at combat crew training stations, where they went after graduation from basic gunnery schools, gunners were required to take each phase check appropriate to their gun position at least five times. The mean number of errors made decreased to zero for many of these latter checks. Table 8.2 presents the average number of errors made on successive phase checks by students taking part in the first try-out of the continuation program of training for combat crew stations.[6]

TABLE 8.2.—*Mean error scores on five successive phase checks of student gunners at a combat crew training station (Pueblo Army Air Base, September 1944)*

Turret	Phase check				
	1st	2d	3d	4th	5th
Emerson	6.29	1.10	0.37	0.22	0.09
Martin	5.41	.41	.14	.00	.00
Motor products	5.69	1.60	.86	.23	.00
Sperry ball	15.23	2.20	.90	.46	.35
Number	199	197	193	192	135

Study of the scores discussed above reveals that a system of phase check scoring indicating simply success or failure was more adapted to the training air force program in its later stages. The small range of errors, and the small proportion of errors to total number of items, made more discriminating scoring impossible in many cases and inadvisable in practically all cases. Training standards for combat crew training stations therefore required that gunners obtain a higher score for graduation than was required at basic gunnery schools.

Two studies were conducted in November 1943, which yielded correlations between the existing phase checks on stripping and

TABLE 8.3.—*Correlation between stripping and assembly phase checks developed at Las Vegas and Buckingham and scores on part III (weapons) of gunnery final examination (GFC) (November 1943)*

Form of phase check	N	r	Phase check scores		Part III, GFC scores	
			M	SD	M	SD
Las Vegas	521	0.13	[1] 21.24	7.32	30.79	2.26
Buckingham	509	.11	[2] 3.75	1.24	31.06	2.35

[1] Score in terms of number of items correctly performed.
[2] Score in terms of errors.

[6] See Chapter 11 for a discussion of the experimental evaluation of this training program.

assembly of the caliber .50 machine gun and the weapons section (part III) of the Gunnery Final Examination (GFC). The results of these studies are presented in table 8.3. Little correlation was indicated between performance on and knowledge regarding the weapon as measured by these instruments.

Use of Phase Checks in the Training of Gunners

Use in basic gunnery schools.—It was recognized soon after their first inclusion in the Training Command gunnery school programs as testing devices, that phase checks also possessed considerable value for training. The principle of "learning by doing" was emphasized and the use of phase checks in the classroom, and by students during their study periods, was encouraged.

The following excerpt is from a description of the basic gunnery program as developed by the Central School:

> Performance or "phase" checks have been developed which are not considered primarily as tests of ability but rather as training aids for the development of adequate skills. In the proposed program there occurs a very minimum of classroom lecture. Even the teaching of part functions and cycles of operation of the caliber .50 machine gun has been planned in such a way that the gunner is actually performing with the gun throughout the period of his learning. The main stress of the new program is upon "operational exercises" in which the gunner, during his training, goes through exactly the same steps he will be required to perform when he joins a combat unit.

Use in training air forces.—It was the success of the training program at Pueblo, however, that finally forced on the attention of gunnery authorities the effective use that could be made of phase checks in the training of gunners. Phase checks were established as the bases for all ground training in the care of equipment in the combat crew training stations. Each gunnery student at these stations was required to take at least five phase checks on the caliber .50 machine gun and on his turret specialty during his course of training. Following is a resume of the use of phase checks for training and testing B–17 gunners included in the standard lesson plan for combat crew stations. Each "unit" refers to a period of training devoted to the care of equipment, and was coordinated with other aspects of crew training. Some units have been omitted.

> Unit 1—*phase check:* Complete phase check on each turret, in addition to Part V of the *Caliber .50 Machine Gun-Care and Cleaning Phase Check.* If a student has not studied his assigned turret in basic gunnery school, he should be taught the complete phase check for his turret during this unit.
>
> Unit 2—*Practice exercise:* Students who have received a "perfect" score in Unit 1 will be excused from this exercise and from Unit 3 as well. Those who have made "perfect" in the turret phase check but not in the weapons part will be sent to weapons laboratory for this unit. Students who have not been phase checked or have not completed their phase check in Unit 1, will complete their phase check in this period.
>
> The rest of the students will be paired off by the assistant chief instructor

before this unit begins, on the basis of similarity of errors in the Unit 1 phase check. Each instructor will then take a pair of students, point out their errors, and then make them correct their own errors by performing the phase check steps correctly. In correcting the student's errors, instructors should supply any additional instruction necessary for a complete understanding of the phase check steps. If time is available, students will use the coach-pupil method nad give the phase check to each other. Students will be rotated with the weapons laboratory so that no men are idle.

Unit 3—*practice exercise:* Each pair of students will be assigned to one turret, as in Unit 2. They will phase check each other, each performing the complete phase check. Instructors will supervise to see that students are performing the steps of the complete phase check properly. They should stress that proper use of the practice exercises will help eliminat malfunctions and braking of equipment in training aircraft. Instructors will use the weekly agmament report on equipment broken on the line as an object lesson in preventive maintenance measures.

Unit 4—*phase check:* All students will be phase checked during this Unit. Assistant chief instructors will rotate students with the weapons laboratory in order to keep all men busy. Students attaining "perfect" will be excused from further class periods up to Unit 7, but they must report to each class to be excused by the assistant chief instructor. Those who made "perfect" on the turret part of the phase check but failed on the weapons part, will be sent to weapons practice exercises until they attain "perfection."

Armorer gunners will be given a complete practice exercise on the Bendix Chin Turret.

Unit 10—*practice exercise:* Same as in Unit 2. Students who attained "perfection" on all previous phase checks will be excused. Excused students will be those who have not only received a perfect score on their assigned position phase check in Unit 7, but also have made no errors on Parts I and III of the phase checks on their two secondary turrets. All other men will be given practice exercises correcting mistakes made on their last phase checks, both primary and secondary. Students who have not been taught all secondary turrets are to have practice exercise on the remaining turrets.[7]

Aerial proficiency check.—The ultimate development of phase checks as training aids was reached with the construction of what were known as flexible gunnery proficiency checks. These checks embraced everything that a gunner might have to do before, during, and directly after a mission except aiming and shooting activities, and were so planned and prepared that actual combat conditions and sequences of activity were closely simulated. In going through the steps required by such a check the gunner not only learned specific procedures but also gained a sense of his whole job.

EVALUATION OF PHASE CHECKS IN FLEXIBLE GUNNERY

It is impossible to estimate accurately how much the use of phase checks contributed to the proficiency of gunners in caring for and preparing their equipment. Despite their theoretical advantages and value, their actual worth was always subject to the effective use made of them. Although they were adopted for use as tests of proficiency in the Training Command gunnery schools early in 1944, they were not widely used in the training of

[7] *Instructors Guide and Lesson Plans, Standard Flexible Gunnery Program for B-17 and B-24 Combat Crew Training Stations*, CSFG, 30 Oct. 1944, pages IV-4 to IV-7.

gunners until early in 1945, when the aerial warfare of Europe was already drawing to a close. Many of the B-29 gunners in the Asiatic-Pacific Theater were trained and assigned to combat duties before the appropriate phase checks had been developed and distributed. Some of the most inclusive phase checks for the training of gunners, the aerial proficiency checks, were brought to completion at just about the time the heavy bombers, for which they were prepared, were being replaced in strategic importance by the larger and more formidable very-heavy bombers.

With these limitations in mind, it is felt that phase checks were of definite value to the flexible gunnery program in the following two ways:

1. They provided an excellent means of training gunners to prepare and care for their equipment correctly, which was the most important secondary aspect of their job. Each time a gunner performed the procedures described in a phase check booklet, he was learning to do part of his job in a way that had proved to be efficient and safe. The use of phase checks in training also ensured that gunners were being trained to do all of the things determined to be essential in the correct discharge of their duties in caring for equipment.

2. They provided a means of ensuring that every gunner who graduated from basic gunnery school, or from a combat crew training station, had reached certain standards of proficiency in the care of equipment.

It was apparent to those who had occasion to work with phase checks in the gunnery training program, that essentially the same testing and training procedures might be applied effectively to many other areas of military and civilian performance. As a direct test of the individual's ability to do an actual job, the phase check has the advantage of almost complete validity over more indirect measures, such as written examinations. Phase checks also provide a sound basis for training by describing accurately and completely how the student should go about his job. In the AAF aircrew training program, phase checks were constructed and used in the training and testing of bombardiers. The British Royal Air Force made considerable use of phase check procedures in the training and testing of gunners using English equipment. Possible civilian applications are too many to enumerate adequately. Suggestive examples are phase checks on the operation of a lathe; the overhauling of an automobile engine; surveying procedures; cabinet making; and appendectomy techniques.

SUMMARY

Flexible gunnery phase checks consisted of complete, detailed descriptions of the behavior involved in operating, caring for, and checking gunnery equipment. They were organized in terms of discrete units of behavior to permit accurate scoring when used as a test and accurate diagnosis of student difficulties when used as a training device. They were first used as tests only, but were gradually used more widely as bases for training gunners in the care of their equipment in the AAF Training Command gunnery schools and in the combat crew training stations of the training air forces. They were instrumental in standardizing the training of gunners in the care and use of their equipment, and they provided a means of ensuring that gunners reached certain standards of performance in such areas. The use of phase checks or of similar performance tests in other types of training programs, both civilian and military, would appear promising.

CHAPTER NINE

The Evaluation of Training Devices and Procedures

Capt. THEODORE R. VALLANCE
and
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INTRODUCTION

During the period between the two wars, and through part of the period just preceding World War II during which the Army Air Forces was expanding, the field of flexible gunnery lay in considerable neglect. With the realization of the importance of heavy bombardment aircraft and of their defense from fighter attack, interest in the training of gunners was rapidly revived.

The people originally assigned to develop a new flexible gunnery program displayed marked energy and ingenuity. Starting with practically no background in gunnery and very little equipment, they accomplished a great deal in setting up efficient physical plants and devising clever and worthwhile training methods and devices. It was unfortunate, however, from a psychologist's or an educator's point of view, that the work was not preceded by more careful planning and experimental evaluation of a psychological nature. Such work might have prevented the adoption and subsequent entrenchment of several training doctrines and procedures of doubtful value, and might have fostered the more rapid development of educational techniques long recognized for their value.

The original Psychological Research Detachments, in seeking suitable measures of various aspects of gunnery proficiency, soon realized the lack of integration in gunnery training methods and in methods for assessing such training. A serious need was apparent for further research directed toward the establishment of a satisfactory criterion of gunnery proficiency and the improvement of gunnery training methods.

The many difficulties involved in the development of a suitable

criterion of gunnery proficiency are described in chapter 5. The following pages are devoted to summarizing experimental evaluations of specific methods used in the training of gunners. The procedure will be, in general, to describe briefly a training device or procedure, to show its place in the training program, and then to summarize investigations of it, giving significant data on the reliability of scores obtained, the amount of learning realized, and the degree of transfer of training to selected criteria. The materials are presented in the approximate order in which a gunnery student would meet each type of training situation while going through school: Ranging and Tracking Trainers, Deflection Trainers, Shotgun Ranges, Machine Gun Ranges, and Air Training Procedures. Within each category, the individual summaries are presented in the approximate chronological order in which the training method was introduced into the program. Two studies, difficult to classify, and a summary conclude the chapter.

RANGING AND TRACKING TRAINERS

In the earlier days of flexible gunnery training, it was considered necessary to give much training in estimation of range. This was due largely to the requirements of the apparent motion system of sighting then in use, wherein the gunner used his sight to estimate the range of a target plane, to determine the speed and line of its apparent motion, and to predict, on the basis of this information, where the plane would be by the time his bullets had covered the estimated range. The gunner could then point the guns at this predicted area.

The Reflectone Trainer

Description.—Several devices were used to train gunners to estimate range. Among those most widely used was the Reflectone Range Estimation Trainer, a device measuring about 10 feet in length by 5 feet in height and 2 feet in width. The gunner looked through an aperture in one end and saw a reflection of a model plane whose apparent range was varied by varying the distance between two mirrors by means of an electrically-driven system controlled by the student. A dial near the student recorded the simulated distance; in addition there were switches controlling the direction of movement of the plane and a knob by means of which its attitude could be varied. The gunner's task was, knowing the wingspan of the plane and the diameter in mils of his sight reticle, to adjust the apparent range of the plane to any given distance (usually 600 yards, since this was considered a critical range for opening fire). The device could also be set with the plane at some selected range and the student required to

report the simulated range of the setting; this was considered a static situation, however, and its use was not encouraged. Some of the early work of the gunnery psychologists was concerned with the evaluation of the Reflectone Trainer. The studies summarized here were concerned with the amount of learning realized on the trainer and the reliability of the scores obtained.[1] Lack of an external criterion prevented studies of the validity of the trainer.

Learning and reliability studies under classroom conditions.—The Reflectone Trainer was observed under both classroom and controlled conditions. In classroom procedure the students were divided into coach-and-pupil pairs. After taking his place at a machine, the pupil attempted to identify the plane and give its wingspan. After correction by the coach as necessary, the student then calculated, or remembered, how much of the radius of his sight would be filled by a plane of the indicated wingspan. He then began actual practice at estimating this range. With the plane approaching him from a distance of 1,000 yards, the pupil would stop the machine when he judged the plane to be at 600 yards. The coach reading the dial, informed the pupil of the direction and magnitude of his error, and recorded his error score. Four such settings were made on each of 10 machines, in which different planes were mounted, after which the procedure would be repeated with the coach and pupil changing places. There was reason to believe that coaches were not as precise in their scoring as they could have been.

An analysis of the scores of three classes revealed that very little learning took place during 15 trials of ten settings each. The data are shown in figure 9.1.

Reliability coefficients for one class (43–22, Buckingham, N=108) were computed using the Kuder-Richardson Formula 20 and found to be 0.75, which was considered satisfactory. It was recognized that this value depended upon the carefulness of the coach in recording scores as well as upon the consistency of performance of the pupil.

Studies of learning under controlled conditions.—Two experimental observations were made to study learning, since it was clear that several uncontrolled factors were influencing the scores derived from the classroom situations.

The first experiment employed as subjects 20 students from Buckingham class 43–22 in their second week of training. None had any previous experience on the trainer. Ten machines were used, containing planes assigned in random order with regard to

[1] These experiments were designed, conducted, and reported by Lt. George J. Wischner.

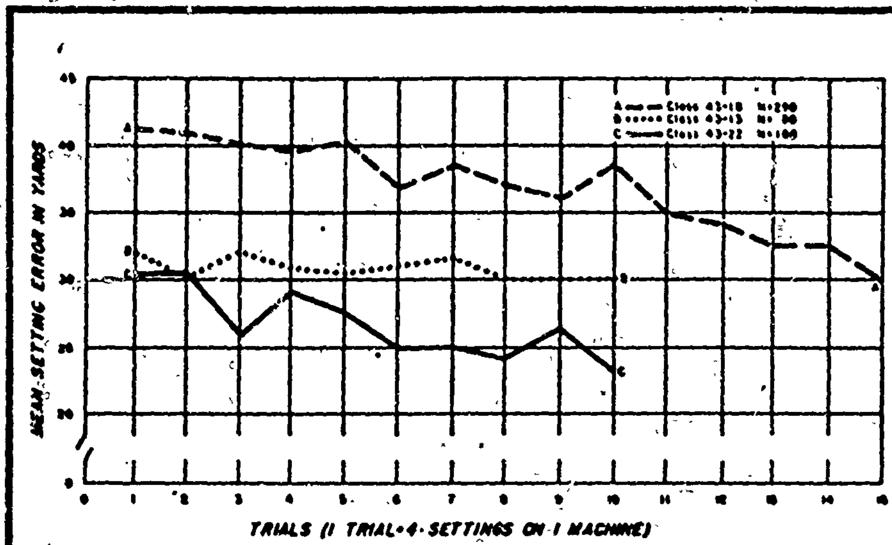

Fig. 9.1—Learning on the Reflectone Range Estimation Trainer; mean scores for three classes in terms of errors, in yards, in adjusting plane to apparent range of 600 yards. (Buckingham, 3rd quarter, '43)

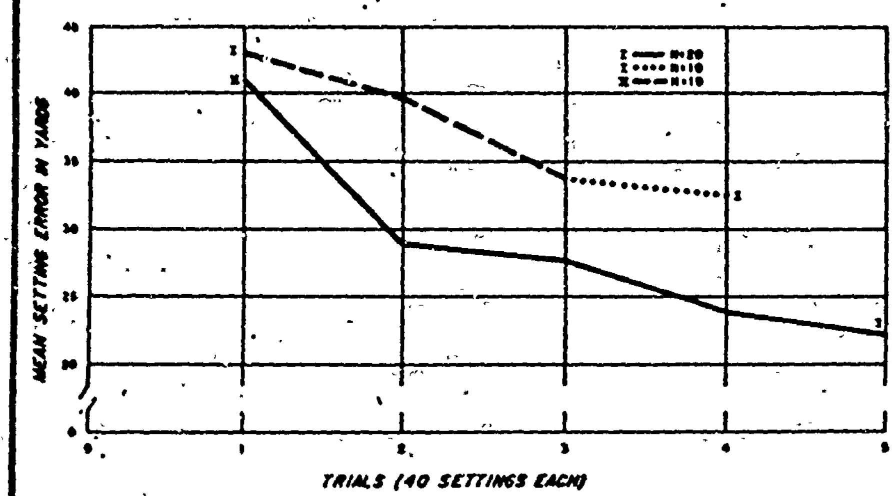

Fig. 9.2—Learning on the Reflectone Range Estimation Trainer; mean scores in terms of errors, in yards, in adjusting plane to apparent range of 600 yards. (two experiments, Buckingham, 3rd. quarter, '43)

the four wingspan classes (30, 35, 40, and 50 feet.) The subjects were divided into two equal groups which were run separately on alternate evenings, with each subject making four consecutive estimates of 600 yards on each of the 10 machines in rotation, a total of 40 settings per session. Subjects were instructed to note their scores after each setting. All subjects were available for three sessions, but only half completed the final session, administrative difficulties precluding the presence of the other half of its last session.

The second experiment was planned to simplify the student's problem and to facilitate learning of a specific performance, namely, the setting of a single plane at a given range. Two trainers were used, both containing Japanese fighter planes of 35-foot wingspan class. The 10 subjects, not gunnery students, were to stop the movement of the plane as it reached 600 yards from an original distance of 1,000 yards; otherwise stated, they were to stop the movement when the plane filled $\frac{7}{12}$ of, or slightly more than half, the radius of the 70 mil sight. Each subject made 40 successive settings daily for five successive days, for a total of 200 settings. Knowledge of results followed each setting.

The results of both experiments are given in figure 9.2, each point representing the average setting error for one session (40 settings). In the first experiment the difference between the first and fourth sessions was 10 yards. In the second experiment, the difference between the initial and final sessions was 18 yards.

In both experiments, statistically significant drops in error occurred only between the first and second trials. The fact that all plotting points for the second experiment were below those for the first was probably due to the greater ease of the task in the second experiment, wherein the subjects had to deal with only one wingspan and only two machines.

Qualitative observations and interviews with the subjects revealed that from the time the subject turned off the motor switch the plane moved approximately another 20 yards. There appeared to be little doubt that the subjects learned to use time cues, brightness cues, and possibly sound cues inherent in the machine in order to improve their scores. As a result of these studies, the amount of time scheduled in the curriculum for practice on this trainer was considerably reduced.

Evaluation.—Although the trainer could be used to assist in aircraft recognition training, and also to give the student practice in deciding which wingspan class a given plane fell in, it seemed that the primary contribution of the trainer should be in the direction of improving the student's ability to differentiate different

proportions in his sight reticle filled by various planes, assuming that this ability was subject to modification. The data reported did not indicate that the trainer modified this perceptual ability appreciably. There was also good reason to suspect that the improvement realized in both the classroom and the experimental situation was due not to improvement in the discriminatory ability, but largely to such things as adaptation to the machine, adjustment to variability between machines, use of extraneous cues, and, particularly, compensation for the amount of error previously indicated on the dial without regard to how much of the radius actually appeared to be filled. It will be noted that in no case did the mean error of the settings decrease by more than 14 yards for the apparent range of 600 yards.

The Full Scale Range Estimation Range

Description.—In an attempt to provide some realistic training in the recognition and estimation of range of aircraft, several outdoor training ranges were constructed at various gunnery schools. In general, these ranges consisted of a large open area across one end of which was a line of sighting stations equipped with 70 mil sights; at proper distance in front of this line there were large signs indicating ranges, usually in multiples of 100 yards. Students called out their estimates of the range of airplanes approaching at low altitudes, and instructors in the target planes used the signs as a basis for radioing the correct range to instructors and students. This was admittedly a very crude sort of training method, and not at all amenable to objective evaluation. A mechanical recorded was developed at one school but was not adopted as standard equipment.

Use of gun camera in range estimation training.—As computing sights became available it became possible to obtain through the use of the gun camera a measure of student performance in operating the sight. The proper operation of a computing sight required that the gunner mechanically adjust a variable set of vertical lines in the reticle to make them equal to the apparent wingspan of the target plane and at the same time keep the center of the reticle on the plane's nose. The Full Scale Range Estimation Ranges, as they continued to be called, offered possibility for economical practice of the skills involved, with evaluation of performance being accomplished through the use of gun cameras, mounted on the sights, which would photograph both the approaching plane and the sight reticle. Las Vegas and Kingman gunnery schools were primarily responsible for developing this range.

Evaluation of use of gun camera.—Early in 1945 an evaluation of this training was directed. Representatives of the Research

Division reported to Las Vegas to observe training and obtain exposed film for analysis. There the sighting line mounted 12 Sperry upper turrets and 12 Sperry lower ball turrets. Each student received 2½ hours of turret operation on the range. The last instruction period was devoted to exposing 25 feet of film per student, each firing at 4 attacks, with the camera operating throughout each attack. In scoring, the tracking error for a given frame was defined as the distance in mils from the center of the reticle to the nose of the attacking plane; the ranging error was defined as the difference in mils between the wingspan of the attacking plane and the distance between the adjustable vertical lines of the sight reticle. If less than five frames per attack were scorable for ranging error or tracking error, the attack was rejected. If a student was scored on less than two valid attacks with respect to either ranging or tracking, his film was rejected altogether.

Scoring and analysis of 8,500 feet of film, thus exposed, revealed some interesting facts.[2] Of the total amount of film exposed, only about 4,000 feet were scorable according to the criteria mentioned above. The rejection of film was mainly attributable to difficulties with photographic techniques. Improper labeling made the differentiation of film from upper and ball turrets impossible. Data are reported for the total amount of scorable film. There were, on the average, 3.6 tracking attacks per student with 11.5 scorable frames per attack, and 3.2 scorable ranging attacks per student with 8.6 scorable frames per attack. Tables 9.1 and 9.2 present the data on the reliabilities of scores obtained. The last column presents estimates of reliability for total score on each pair of measures studied, based on the Spearman-Brown formula.

TABLE 9.1.—*Intercorrelations of Sperry ranging errors: Means and standard deviations, in mils; and product moment coefficients (Las Vegas, first quarter, 1945)*

Variables correlated	N	M	SD	r[1]	r[2]
Attack 1 vs	114	10.11	5.86	0.32	0.49
Attack 2	114	10.98	7.45		
Last attack vs	114	10.84	7.20	.40	.57
Next-last attack	114	10.20	6.91		
Average odd vs	114	10.23	5.71	.41	.58
Average even attacks	114	10.80	7.15		

[1] Obtained r.
[2] Reliability corrected by Spearman-Brown formula.

[2] The project officer for this study was Lt. Eston W. Ray, who was assisted by Lt. Thomas P. Gallagher.

It is seen that neither ranging nor tracking scores based on the small number of scorable attacks obtained under the established procedure, had sufficiently high reliability to provide a fully satisfactory measure of a student's proficiency.

TABLE 9.2.—*Intercorrelations of Sperry tracking errors: Means and standard deviations in mils; and product moment coefficients (Las Vegas, first quarter, 1945)*

Variables correlated	N	M	SD	r[1]	r[2]
Attack 1 vs Attack 2	192 192	7.57 7.10	3.58 3.12	0.44	0.61
Last attack vs Next-last attack	192 192	7.20 6.40	3.26 2.74	.44	.61
Average odd vs Average even attacks	192 192	7.51 6.91	3.28 3.00	.37	.54

[1] Obtained r.
[2] Reliability corrected by Spearman-Brown formula.

Conclusions.—As a result of this study it was recommended that unless the amount of film exposed could be sufficiently increased and the developing and scoring of the film done with extreme care, the use of film on the range should be eliminated as superfluous. The observed shortcoming of the use of gun camera film on the range was recognized as not due to the ineptness of those who planned it. The limited amount of film available was insufficient and could not be increased because air training commanded first priority on film stocks and processing facilities; the range used only odds and ends of film left over. It was pointed out, however, that the practice realized by gunners in loading and operating gun cameras would be worthwhile as training in transition to the air phase, but the time and personnel required for developing and scoring the film was considered as not worth the small and dubious benefits derived.

RCAF Range Estimation and Aircraft Recognition Trainer

Another device considered for teaching range estimation was one developed by the Royal Canadian Air Force.

Description.—This was a device which consisted of three main parts. There was a set of 12 gimbals mounted in 2 banks of 6 each, 1 approximately 2 feet above and to the rear of the other. Each gimbal mounted a Mark 11A fixed optical sight (a Canadian model similar to the N–6) which showed a 70-mil reticle; a trigger button was located on the right handle of each unit. There was a motion picture projector which used a 16mm. film of 11 minutes duration showing head-on attacks by German and Allied aircraft.

And there was a paper tape recording machine synchronized with the projector. From the start of each attack an automatically energized solenoid caused a key to record along one edge of the tape each 100 yards of progress represented by the picture. The recorder also contained a recording key for each sighting station, which registered when the student at each station indicated, by pressing the trigger button, the approaching plane to be at any specific range. The amount of error in each student's estimate was read through a transparent scale based upon the distance between the 100 yard marks.

The device gave practice in the recognition of aircraft and in learning the amount of a sight reticle that would be filled by a wingspan of a given length at a given range. However, since these two things could be taught by other less complicated means, it was decided that the trainer would be evaluated for its contribution to the guner's ability to make the perceptual judgment of just when a known proportion of the diameter of the sight reticle was filled by the expanding wingspan of an approaching plane.

Experimental procedure.—Twelve basic gunnery students who had completed 4 weeks of training, including sighting and the use of optical sights in the estimation of range, served as subjects in the experiment.[3] Nineteen trials of 20 attacks each were given in 9 sessions over a period of 17 days. Before each attack the name of the plane, its wingspan, and the approximate proportion of the reticle which the wingspan should fill at 600 yards range was read to the subjects. After each attack the apparatus was turned off, and the ranges which the subjects had estimated to be 600 yards were read by the experimenter. After each trial the subjects were given a 10 minute rest, during which time the film was rewound. The same film was used throughout the experiment. The twelfth trial consisted of an individual test for each subject, the main purpose of this being to determine the suggestion effect occasioned by the ability of each subject to hear the buzz of the recorder each time another subject indicated his judgment that the target plane had reached 600 yards. The nineteenth trial was also an individual test intended to determine whether or not individual performance as measured at trial 12 had been improved by further group practice.

Two measures were used and computed for each trial: (a) the arithmetic means of errors, i.e., the mean of estimates regardless of whether over or under 600 yards, and (b) the standard deviation of the actual estimates. The computation of the second

[3] The experiment was directed by Capt. Theodore Vallance, assisted by Lt. James F. Lawrence.

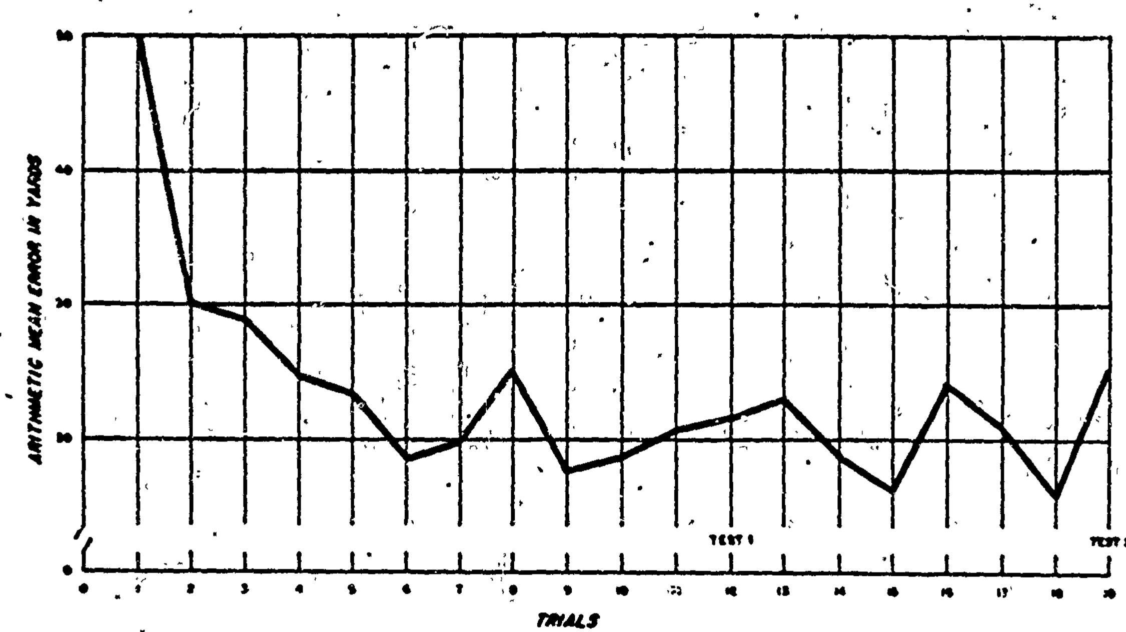

Fig. 3.3—Arithmetic mean error in yards of estimating range of 600 yards on the RCAF Range Estimation Trainer, [illegible], [illegible], 4th quarter, [illegible]

measure turned out to have been somewhat superfluous since it correlated 0.993 with the first.

Experimental results.—The results of the practice are shown in table 9.3 and are graphically portrayed in figure 9.3.[4] Learning did occur in the early trials, but it is seen that there was no definite trend of improvement beyond the seventh trial. Results on the two individual trials (12 and 19) were not conclusive. Trial 19 was given after the students had completed their gunnery training, so that the relatively poor performance on this trial was attributed in part to loss of interest in the experiment. Scores on trial 12 suggested that the effect of hearing the buzzers on the group trials was not particularly great.

TABLE 9.3.—*Learning on the RCAF range estimation trainer: Arithmetic mean errors, in yards, in estimating ranges of 600 yards (N=12, Buckingham, 4th quarter, 1943)*

Trial	N (judgments)	Mean error	Trial	N (judgments)	Mean error
1	212	49.84	11	239	20.71
2	224	30.02	Test 1 12	240	21.71
3	225	28.90	13	240	22.94
4	240	24.71	14	240	18.58
5	240	23.40	15	239	16.23
6	240	18.60	16	239	24.06
7	240	19.79	17	239	20.84
8	240	25.00	18	239	15.80
9	240	17.60	Test 2 19	240	25.27
10	240	18.65			

As a result of these findings it was recommended that the trainer be adopted for general use as a range estimation trainer, but nothing came of this because it was later decided to reduce the emphasis on training in range estimation.

The E-8 Spotlight Trainer

Background and description.—One of the earliest tracking training procedures in flexible gunnery made use of a turret situated in a shed, the ceiling of which was a quarter of a sphere, having a radius of about 10 feet, with its lowest part approximately on a level with the top of the turret. Painted on this ceiling were several curved and straight lines. It was the task of the gunner in the turret to track, following these lines. After a few minutes of this practice gunners usually became bored and lost interest. The advent of the E-8 Spotlight Trainer greatly improved the value of this general form of tracking practice. The E-8 consisted of three parts: an electrically-driven, cam-controlled projector which projected a moving spot of light on the

[4] In most instances where learning curves are presented, they are accompanied by tables to provide more accurate numerical data.

ceiling; a photo-electric cell mounted on the turret in place of guns and harmonized with the sight; and a shot and hit counter unit which recorded shots when the student had his triggers depressed, and hits whenever the photo-cell was pointed directly at the spot of light while the triggers were depressed. The recorder contained a sounder which could be set to represent either shots or hits. The E-8 appeared to be quite well constructed, for only a relatively small amount of mechanical failure was reported. The sound of shots being fired or of hits being scored enhanced students' interest in the practice.

The value of the trainer in the form just described was limited by the fact that the sight had to be pointed directly at the target (spot of light) in order for hits to be recorded. Clearly the training was of no value in developing proficiency in using the Position Firing system of sighting, which required the laying off of deflections varying in size according to the angle of the target from the bomber's line of flight. That the trainer was of value in developing familiarity with the turret and skill in its manipulation was never seriously questioned.

The Sperry Gyroscope Company developed a variation of the E-8 for use with computing sights. The problem presented by this modification required that the gunner, by controlling the sight's adjustable reticles, frame a variable-sized spot of light which moved about the ceiling. With the sight pointing directly at the spot and the reticles being the proper distance apart, hits would be recorded when the gunner pressed his trigger. Although this form of the trainer provided probably useful practice in the operation of computing sights and produced satisfactory motivation of students, the scores which it yielded were not very reliable. Attempts were continually under way to improve the device. One such improvement was on the verge of adoption at the close of the war.

Reliability of scores.—At one time the scores on the Spotlight Trainer were used as a part of the gunner's permanent record.

A reliability study on this trainer was conducted, using the records of approximately 300 students, each of whom fired 2 trials of 1,000 shots.[5] The students were divided at random into 43 groups averaging 7 men each, and each group was assigned to a specific turret. Prior to the first test trial, each subject had had approximately 3 hours of actual turret manipulation. The second test trial was given 1 week after the first and was preceded by an hour of practice. It was found that a gain in percent hits

[5] This investigation was conducted and reported by Lt. John G. O'Hara.

occurred on the second trial, and that this gain was significant at the 1 percent level, as reported in table 9.4.

TABLE 9.4.—*Test-retest reliability of E–8 spotlight trainer scores and reliability of gain on second trial for trials of 1,000 shots each (approximately 300 cases, Buckingham, April 1944)*

Trial	Mean percent hits	SD	SE_M	Diff	Reliability[1] of one trial
1	64.44	12.96	0.713	[2]4.44	0.42
2	71.88	12.75	.701		

[1] Product-moment coefficient corrected for heterogeneity of samples. See May, M. A., A method of correcting coefficients of correlation for heterogeneity in the data, *J. Educ. Psychol.*, 1929, *20*, 86–92.
[2] A difference as large as that obtained would be expected to arise by chance less than 1 time in 100.

As a means of determining whether significant variations in the scores obtained by students assigned to different turrets occurred, the reliability of the difference between the mean of each of the 43 sub-groups and the mean of the total group was calculated. It was found that 18 of the 43 differences were reliable at the 1 percent level. It was considered that this variation was the result chiefly of differences in the functioning of the various trainer units, since the 43 groups were formed unsystematically.

The correlation between scores on the two trials was found to be 0.61. It was believed, however, that this was an over-estimate of the reliability in view of the evidence of differences among turrets. As reported in table 9.4, the estimate of reliability, after correction for heterogeneity among the groups, turned out to be 0.42. As a further estimate of reliability, Spearman rank difference correlations were computed for each of the 43 groups separately. The mean of the rho's so obtained was 0.42. This value may be considered to be a conservative estimate of the reliability of these scores.

On the basis of this study, it was recommended that scores on the E–8 trainer not be used to compare students with one another.

Learning on the E–8 Trainer.—That learning could be obtained on the Spotlight Trainer was shown in a study conducted at Buckingham in 1944, wherein 20 untrained gunners were given 27 trials of 10 minutes each in the Martin turret.[3] The mean percent of hits on each trial is reported in table 9.5 and figure 9.4. It will be noted that after about the twentieth trial proficiency ceased to be improved appreciably.

[3] The project officer for this study was Capt. Mason Haire, who was assisted by Sgt. Rudolph Goodman.

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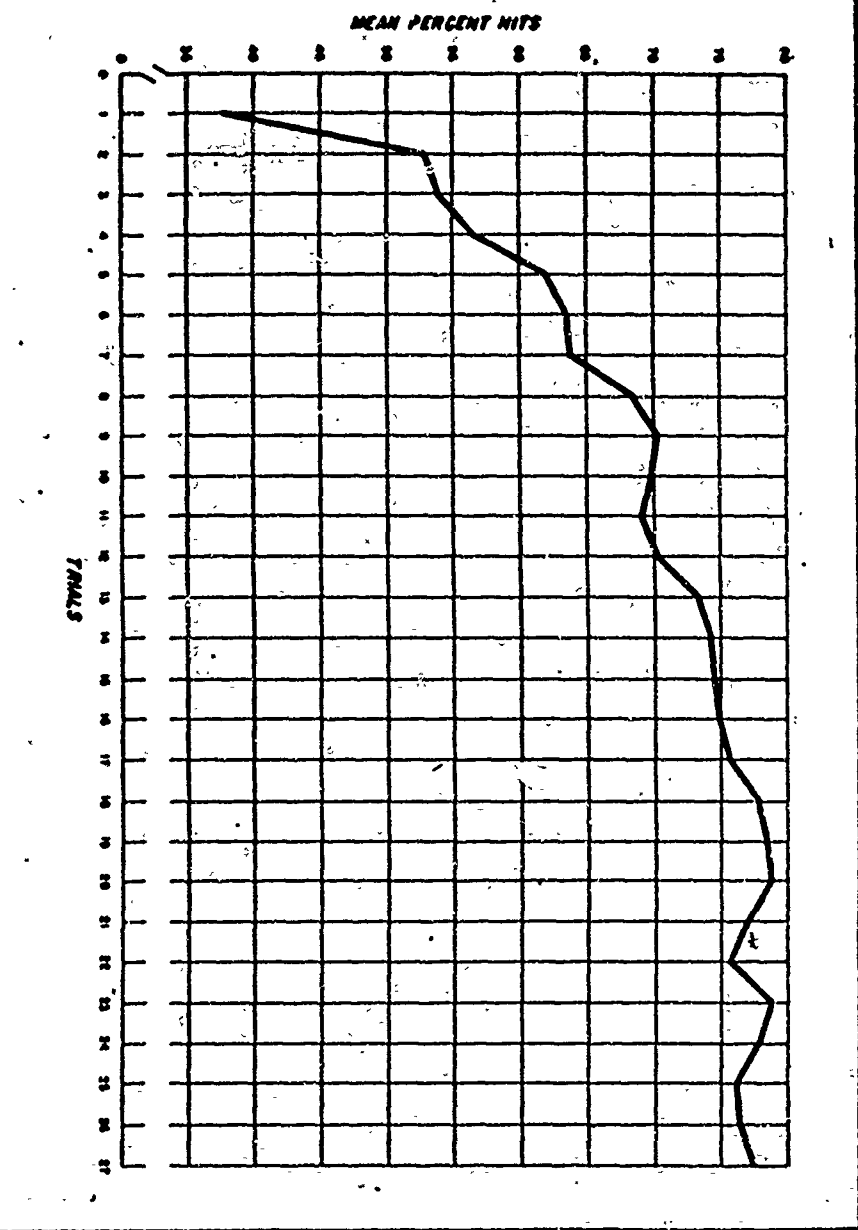
MEAN PERCENT HITS
TRIALS

TABLE 9.5.—*Learning on the E-8 spotlight trainer: Mean percent hits obtained by 20 untrained subjects on each of 27 trials. (Buckingham, first quarter, 1944)*

Trial	M	Trial	M
1	37.6	15	74.5
2	53.0	16	74.9
3	53.9	17	75.7
4	56.5	18	77.7
5	61.9	19	78.4
6	63.6	20	78.8
7	63.8	21	77.0
8	68.5	22	75.6
9	70.2	23	78.8
10	69.7	24	77.8
11	69.0	25	76.1
12	70.1	26	76.4
13	73.0	27	77.6
14	74.2		

Transfer of training.—It was generally agreed that the Spotlight Trainer was probably an excellent practice device, but no objective tests of the validity of this agreement were conducted until the 3d quarter of 1944, when an experiment was conducted in collaboration with the Department of Psychology of the School of Aviation Medicine for the purpose of determining the influence on gun camera proficiency of practice on the Sperry modification of the Spotlight Trainer.[7] The details of the pretest and post-test gun camera missions and the method of scoring gun camera film are described in the sections of this report dealing with the DeVry Panoramic Trainer and with the gun camera.

Following the 3 pretest gun camera missions, the 16 graduate gunners who flew their missions in the Sperry upper turret were given 24 trials on the Sperry modification of the Spotlight Trainer at an average rate of 2 trials daily; each trial lasted for 15 minutes. After this practice, the subjects flew three more gun camera missions as before. The pretest and post-test scores and the magnitude and significance of their differences are shown in table 9.6.

TABLE 9.6.—*Gun camera proficiency as influenced by practice on the Sperry spotlight trainer: Means, standard deviations, and significance of differences between means of mil errors in framing and tracking with the Sperry upper turret on 3 missions before and after practice on the spotlight trainer (N=15, Laredo, third quarter, 1944)*

	Missions 1–3			Missions 4–6		Diff.	SE_{diff}	t
	N	M	SD	M	SD			
Tracking	15	8.99	1.78	7.62	2.02	1.37	0.54	[1] 2.54
Framing	15	7.41	2.92	6.82	1.65	.59	.85	.69

[1] Difference would occur by chance less than 2 times in 100.

[7] Capt. Moncrieff H. Smith represented the School of Aviation Medicine; Capt. Mason Haire, and S/Sgt. Riner C. Payne represented the Research Division.

The Sperry framing error showed no significant change as a consequence of practice on the Spotlight Trainer, but the Sperry tracking error showed a decrease significant at the 2 percent level. Despite the unreliability of scores derived from the training period (see below) the trainer apparently did give some worthwhile practice in tracking. This interpretation must be considered tentative in the absence of a control group.

Information on the reliability of the scores derived from the Sperry modification of the E-8 was obtained in this study. Though no data were reported on the reliability of the training scores, the report of the project indicated that within a single day the scores obtained varied as much as 1,000 percent, and that within the entire period of training they varied 10,000 percent, making a detailed statistical analysis of the scores hardly worthwhile.

B-29 Manipulation Trainer

Description.—The only ground range used in the B-29 training program which involved a relatively new departure was the Manipulation Trainer. On this range the gunner, using standard B-29 sighting equipment mounting gun cameras, was required to track and frame fighter planes flying attacks on ground positions. The gun camera film provided a record of performance. (A similar range had been used at Kingman in training basic gunners but this was never adopted as a part of basic gunnery training.)

Learning on the B-29 Manipulation Trainer.—A learning curve for B-29 tracking and framing scores was determined on the basis of the performance of 202 gunners, in class 225 at Buckingham.[8] Class 225 was one of the first classes to use this range as part of the 12-week course for B-29 gunners. Data represent scores made on practice during February and March of 1945. In addition to scored trials, the gunners were given an unspecified amount of "dry tracking" practice on this range during this period. Moreover, since the trials were given at intervals of about a week, training on other ranges and trainers may have affected proficiency. The learning curves for average errors in tracking and framing are shown in figure 9.5, and the supporting data in table 9.7. It is apparent that improvement occurred on this trainer, and that the improvement in scores was relatively more rapid during the first two trials. However, at least four trials on this range appeared to be desirable.

[8] This study was made by Lt. Ingraham Humphrey and Cpl. Jerry Gibian.

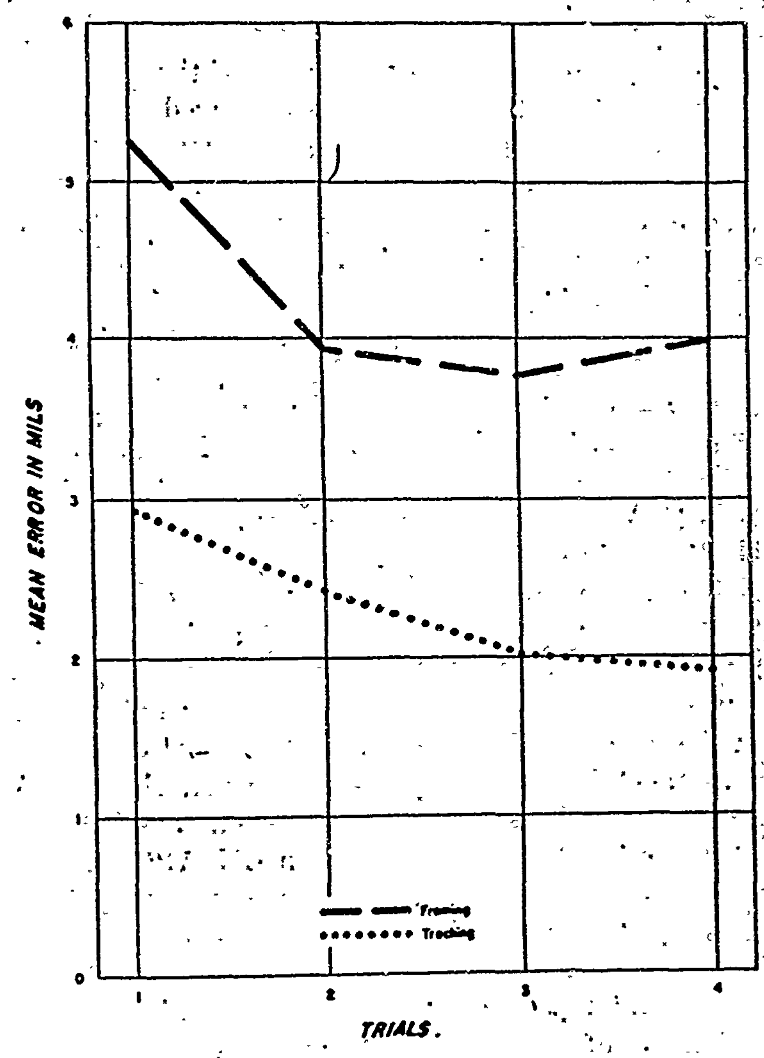

Fig. 9.5 Learning on the B-29 Manipulation Trainer: mean error in framing and in tracking on 4 successive trials (N=202, Class 225, Buckingham, Feb.-Mar., '45)

TABLE 9.7.—*Learning curve data for tracking and ranging errors on B–29 manipulation trainer (N=202, class 225; Buckingham, February-March 1945)*

Trial	Framing error (in mils)	Tracking error (in mils)	Trial	Framing error (in mils)	Tracking error (in mils)
1	5.25	2.93	3	3.76	2.01
2	3.94	2.41	4	3.98	1.92

No studies of reliability or validity of this range were done. It was apparent that the practice on the use of equipment provided on this range was quite realistic. In view of the fact that combat type sighting equipment was used, it appeared that practice on this range had a reasonably good chance to transfer to proficiency in tracking when the turret is mounted in an airplane in flight. In the absence of a specific validating study, no adequate estimate could be made of the degree to which such transfer, if any, would occur.

The AN/APG–15 T1 Trainer (Radar)

Description.—The introduction of radar equipment to make possible bomber defense during night missions provided a new training problem. One particular type of radar equipment, designated the AN/APG–15, permitted the gunner in combat to aim at approaching fighters by super-imposing intersecting cross-hairs in the center of a small oscilloscope window upon a spot of light appearing on the same window. By moving his guns, the gunner caused a radar attachment to search various areas of the sky for planes. When a plane was picked up, a spot of light appeared on the oscilloscope. The gunner tracked the spot of light. When mounted in the tail position in B–29 aircraft, the AN/APG–15 device was used in connection with the usual equipment for the remote control of B–29 tail guns. When AN/APG–15 equipment was used, the gunner had to move his guns downward when the spot of light appeared above the intersection of the cross-hairs, to move his guns to the right when the spot of light appeared to the left of this intersection, and vice versa. This was a reversal of habitual modes of response in aiming and tracking and required an adjustment somewhat similar to that required in the traditional mirror-drawing experiment.

The AN/APG–15 T1 Trainer was designed to duplicate, in so far as possible, the gunner's task in using AN/APG–15 radar equipment in tracking. In this trainer, the gunner used the "scope" and the sighting station for the remote control of his "guns." The path of the spot which indicated the successive locations of an attacking plane was controlled by appropriate

cams which provided target paths similar to those to be expected in combat. The fact that in combat the gunner had to rely during night attacks entirely on the information given by his radar equipment tended to enhance the similarity between trainer and combat conditions.

Reliability of AN/APG–15 T1 scores. An experimental study of this trainer was carried out at Laredo during June and July of 1945.[a]

A total of 18 graduate gunners were selected at random from the pool of students awaiting training. None of these students had had previous experience either with B–29 sighting stations or with radar equipment. The students were given a short orientation course covering the purpose of the study, were familiarized with the function and operation of the pedestal sighting station used in the B–29 tail position, were given 10 minutes of practice manipulation, and were shown a training film on radar equipment. They were also given an initial trial of 8 minutes duration on the trainer as part of the orientation.

A total of 11 training trials, each involving four 2-minute practice periods, was given to each of the 18 subjects. One trial was given each day. Scores were obtained from error integrator units mounted on the trainer, which provided an index of the amount of angular error in azimuth and in elevation separately during the course of each trial.

Estimates of the reliability of total scores on 11 trials, presumably obtained by use of the Hoyt method, were obtained for each type of score. For all 11 trials, the reliability of azimuth scores was estimated to be 0.84; that of elevation scores, 0.86.

Learning on the AN/APG–15 T1 Trainer.—The change in proficiency during the course of 11 trials is shown in table 9.8 and in figure 9.6. It was found that a considerable amount of learning occurred during the training. The curve for azimuth tracking appeared to show more improvement during the later trials than was the case for elevation tracking. These scores, however, represented two aspects of the underlying performance of tracking. It was recommended that at least 11 trials of 8 minutes each be provided for practice on the AN/APG–15 T1 Trainer.

No studies of the validity of this trainer or relationships with other trainers were carried out. The trainer was judged, on the basis of the evidence of learning and of the relatively high reliability of scores, to be a satisfactory training device when properly maintained.

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[a] The project officer for this experiment was Capt. Alfred C. Jensen, assisted by Cpl. Walter Cohen. Lt. Ralph F. Wagner assisted materially in developing the trainer to its final state.

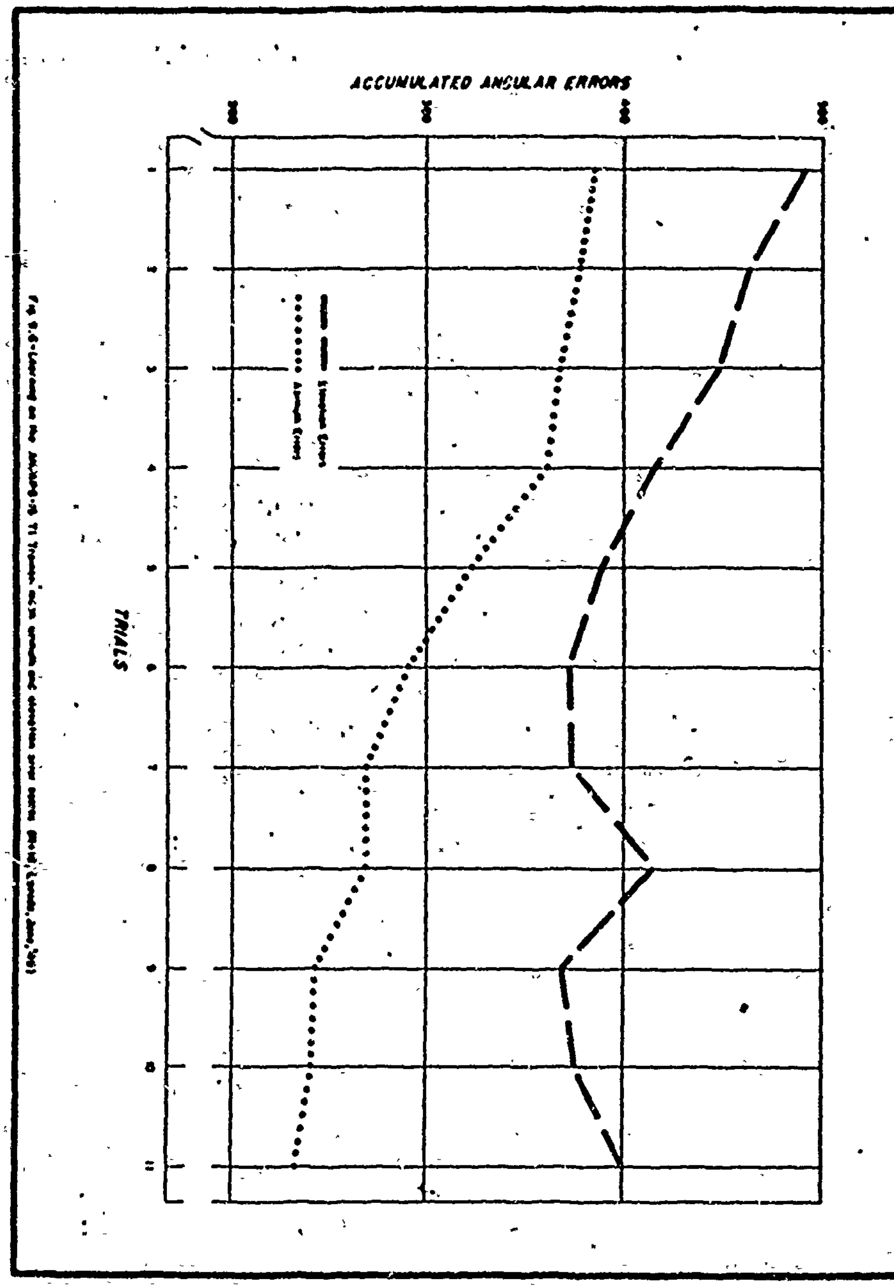

ACCUMULATED ANGULAR ERRORS
TRIALS

TABLE 9.8.—*The course of proficiency on AN/APG–15T1 trainer: Means and standard deviations of accumulated angular error scores for azimuth and elevation on 11 successive trials (N=18, Laredo, June 1945)*

Trial	Azimuth errors		Elevation errors	
	M	SD	M	SD
1	385	67	491	95
2	378	57	462	73
3	367	55	447	99
4	361	56	414	85
5	322	41	389	36
6	291	45	372	61
7	269	23	374	34
8	269	29	414	41
9	242	26	369	28
10	241	22	375	45
11	232	28	399	39

It is interesting to note that the AN/APG–15 T1 Trainer occupied a unique position among flexible gunnery trainers, in that its development was undertaken concurrently with the development of the AN/APG–15 gunnery unit itself. In every other known instance of synthetic trainer development, the trainer had to be improvised some time after the equipment concerned had been in production or even in combat. By being planned along with the radar gunnery equipment, the AN/APG–15 Trainer was ready for use with a minimum of delay after it was needed.

DEFLECTION TRAINERS

The most complicated and difficult task in gunnery involved the coordination of the motor skills required to operate a turret or hand-held gun, with the ability to judge accurately and then apply the amount of deflection required for each of a large variety of fighter attacks. Much time and effort were devoted to developing devices which would give gunnery students' initial training and continuing practice in the requisite skills.

The Waller Trainer

Although originally developed for the Navy, the Waller Trainer became one of the mainstays of the Army's flexible gunnery training program, particularly for the training of basic gunners.

Description.—Designed to duplicate the gunner's problem of sighting, aiming, and triggering in so far as it could be simulated by a ground training device in which no live ammunition was fired, the trainer was necessarily elaborate. It required a specially designed building to provide space for a large screen on which fighter attacks were projected. This screen took the form of a segment of the inside surface of a sphere, covering almost 170° in azimuth and about 55° in elevation. The large screen

surface was intended to correspond roughly to the segment of the sky which the typical gunner might be required to scan for enemy aircraft and in which his fire would be effective. A battery of five synchronized motion picture projectors was required to depict events occurring in various areas of this "sky." Attack films for these projectors were obtained by photographing fighter planes attacking a bomber.

For dealing with these attacks, the gunner was provided with equipment bearing sighting devices similar to those in use on combat planes. Although his guns did not resemble machine guns in appearance, the grips were designed so that marked vibration could be introduced into them. In some training installations, combat-type turrets were mounted in order to give the gunner practice in turret manipulation. Intercommunication equipment was also included. In addition to giving the gunner practice in its use, the interphone equipment provided means for individual coaching by an instructor without interruption of the firing, for simulating plane noises typical of combat, and for giving immediate knowledge of correct timing and firing by sounding a tone whenever a hit was scored. This tone, usually termed the "beep-tone" because of its high pitch, could be turned on or cut off by the instructor.

The scoring system for this trainer provided for recording both "shots" and "hits." The number of shots was obtained from a counter which accumulated units at a constant rate during each period when the gunner was pressing the trigger. The number of hits was obtained from a counter which accumulated units at the same rate whenever the gunner had his sights properly aligned and was triggering. The correctness of the gunner's sighting was determined by a specially designed film (called the scoring band) synchronized with the attack film so that if the sights were lined up properly, a photo-electric system was activated. The design of a scoring film presented serious technical difficulties, since it had to correspond to the correct point of aim at each point of an attack. During the greater part of the war, the usefulness of the Waller Trainer was severely impaired by the difficulty of obtaining attack films representing typical pursuit curves and scoring bands appropriate to these attacks. Moreover, the maintenance of uniform sensitivity of the sensing system represented a persistent problem.

In addition to scorable attacks, the Waller Trainer films included so-called point-of-aim attacks, in which the correct point of aim was shown. This feature was intended to help the gunner learn the correct deflection for various phases of the attacks.

The typical installation provided opportunity for four students

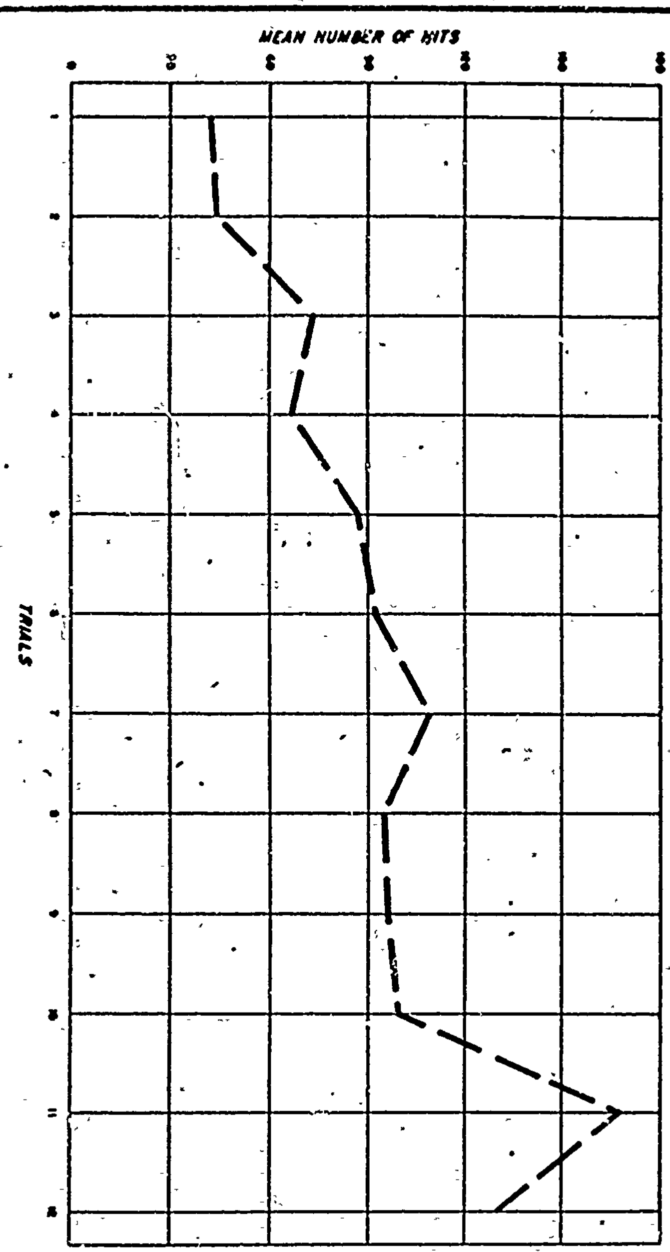
to fire and receive scores at one time. Equipment was included which permitted eight additional students to track the airplanes with swivel-mounted wooden "guns." It was frequently noted, however, that gunners did not find this "dry tracking" practice interesting.

Reliability of scores.—In May of 1943, a study of the reliability of Waller Trainer scores was carried out at Buckingham in an effort to evaluate the desirability of using these scores as a basis for eliminating students from gunnery school.[10] In this study, two methods of scoring performances were considered. The first, which was then in use at Buckingham, involved computing the percent of hits, and then assigning systematic penalties for deviations from the optimum number of shots and for deviations from the optimum number of bursts. The "optimum" number of shots and bursts and the system of penalties for deviations were determined by expert opinion. The second method utilized the number of hits during a trial directly. Reliabilities of scores obtained in accordance with each of the two systems were obtained by analysis of the training records of students in Class 43-26, Buckingham, and by training under controlled conditions a group of 12 graduate gunners, students in the Instructors School, who volunteered to serve as subjects. For the school records, reliability of scores (of gunners in class 43-26, Buckingham) on 2 test films was found to be 0.19 for the more elaborate scoring system and —0.01 for hits only. Under experimental conditions, however, the reliabilities of the scores of 12 gunners were found to be 0.44 for the adjusted scores and 0.59 for the hit scores. Moreover, a reliability of 0.80 was obtained for hit scores when scores on 8 tests were combined. These results were interpreted as indicating that improvement in reliability of Waller Trainer scores was needed before they could properly be used as an adequate index of proficiency, and as showing that such improvement could be obtained by proper control of testing conditions.

Learning.—As part of the study described above, a learning curve based on the records of the 12 Instructors School students for each of 12 trials was obtained. All trials were conducted on Test Film 101. The course of learning on this film, as indicated by mean score on each trial, is shown in figure 9.7. It was concluded from these data that a marked increase in proficiency occurred and that it was probable that further increases would occur with further training.

In the summer of 1945, a more elaborate study of learning on

[10] This study was done by Lt. Arthur L. Irion.


MEAN NUMBER OF HITS
TRIALS

this trainer was carried out at Laredo.[11] This experiment was designed to explore the rate and extent of learning on the trainer, the effect of practice on the training films upon performance on test films, and the effect of the "beep-tone" upon performance.

For this study, 64 men awaiting assignment to gunnery training were selected at random. Following an orientation in sighting methods, they were given a pretest on the trainer, using Test Film 7, without the "beep-tone." They were then divided into 4 groups of 16 each in such a way as to give each group approximately the same mean and standard deviation on pretest scores.

In accordance with the objectives described above, the daily training programs for each of the 4 groups were designed in the following manner:

Group I gunners received training on 3 training films and were then tested on Test Film 7 daily. They were given knowledge of their results by use of the "beep-tone" on the *first 5* test trials only. (They had this information on the training films during the first 4 days).

Group II gunners received the same training films as Group I and were tested on Test Film 7 daily. However, they were given knowledge of their results by use of the "beep-tone" on the *last 5* test trials only. (They had this information on the training films during the last 4 days).

Group III gunners received no practice on the training films, but were tested on Test Film 7 daily. They were given knowledge of their results by use of the "beep-tone" on the *first 5* days only.

Group IV gunners received no practice on the training films, but were tested on Test Film 7 daily. They were given knowledge of their results by the "beep-tone" on the *last 5* days only.

By this arrangement, it was possible to estimate the contribution to proficiency made by the training films and to obtain information regarding the effect of withdrawing the "beep-tone," a point of some importance in dealing with the argument that this signal was used as a "crutch" by students to the detriment of their mastery of the trainer.

It should be noted that the use of only one test film, although desirable in simplifying the experimental design, had the disadvantage that students might become sufficiently familiar with the specific attacks in the test film that their score reflected this familiarity as well as skill in the procedures the test film was designed to measure.

Each gunner fired from the same gun position in the same trainer during each trial. This prevented distinguishing between variations in scoring sensitivity of the particular positions and individual differences in proficiency. However, since each position was fired an equal number of times by each of the four groups, variations in scoring among the positions did not enter into the group results. The possibility that the equating of the

[11] This experiment was conducted by Lt. Daniel J. Histon and Lt. Esten W. Ray.

four groups was invalidated to some extent by variations in scoring was not investigated.

The basic results of this study are presented in table 9.9. Certain combinations of the data to facilitate comparisons provided the basis for Figures 9.8 and 9.9. On the first test trial, the groups receiving the training films showed a superiority which they maintained at approximately the same level during the eight training trials. It was further found that the groups receiving knowledge of results excelled their counterparts who were not receiving knowledge of results by a rather uniform margin throughout the eight trials. When the groups receiving the "beep-tone" were reversed following the third trials, the relative proficiency also was reversed, but the "no-beep" students improved during the final four trials by approximately the same amount as the students who received knowledge of results in this form. Although the design of the experiment prevented the determination of a learning curve which would be representative of the course of improvement under uniform training conditions throughout the series of eight trials, the similarity in the trends shown in the four curves appearing in figures 9.8 and 9.9 suggested that marked improvement in proficiency did occur under each condition of training and that further trials under these conditions would be likely to produce additional important increments of proficiency.

TABLE 9.9.—*Mean Waller trainer scores on eight successive trials for four groups of previously untrained gunnery students trained under four different systems (N=16 for each group, Laredo, July 1945)*[1]

Trial	Training films		No training films	
	Group I	Group II	Group III	Group IV
1	107 *	91	91 *	43
2	126 *	87	71 *	77
3	142 *	92	77 *	76
4	123	170 *	98	116 *
5	126	190 *	115	136 *
6	193	237 *	146	166 *
7	164	199 *	156	170 *
8	210	243 *	168	183 *

[1] All entries obtained from graphical presentation of data in earlier report. An asterisk following an entry indicates that members of the group heard the "beep-tone" immediately following each hit scored during the trial.

The E–14 or "Jam-Handy" Trainer

The "Jam-Handy," or E–14, Trainer was one of the oldest and most versatile devices used in the training of flexible gunners. The name "Jam-Handy" came from the name of the organization in Detroit which originally developed the trainer for the United

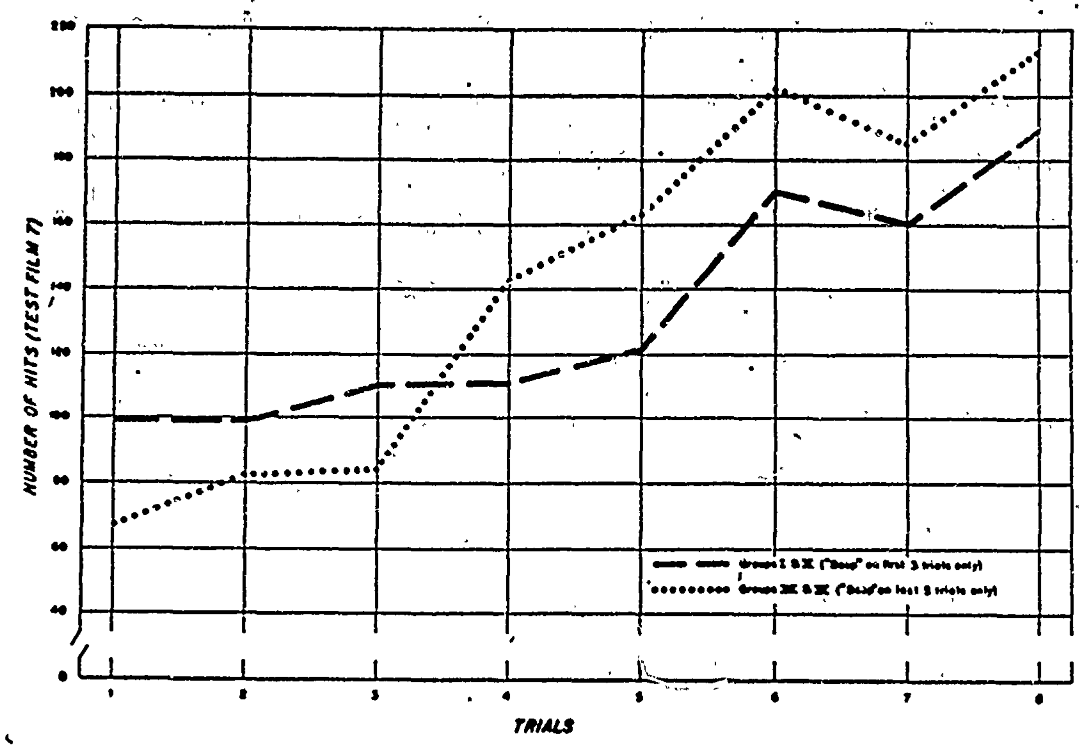


Fig. 9.8 – Course of proficiency on Waller Trainer for 32 students who received the "Beep-Tone" on the first 3 trials only and for 32 students who received the "Beep-Tone" on the last 5 trials only (Laredo, July, '46)

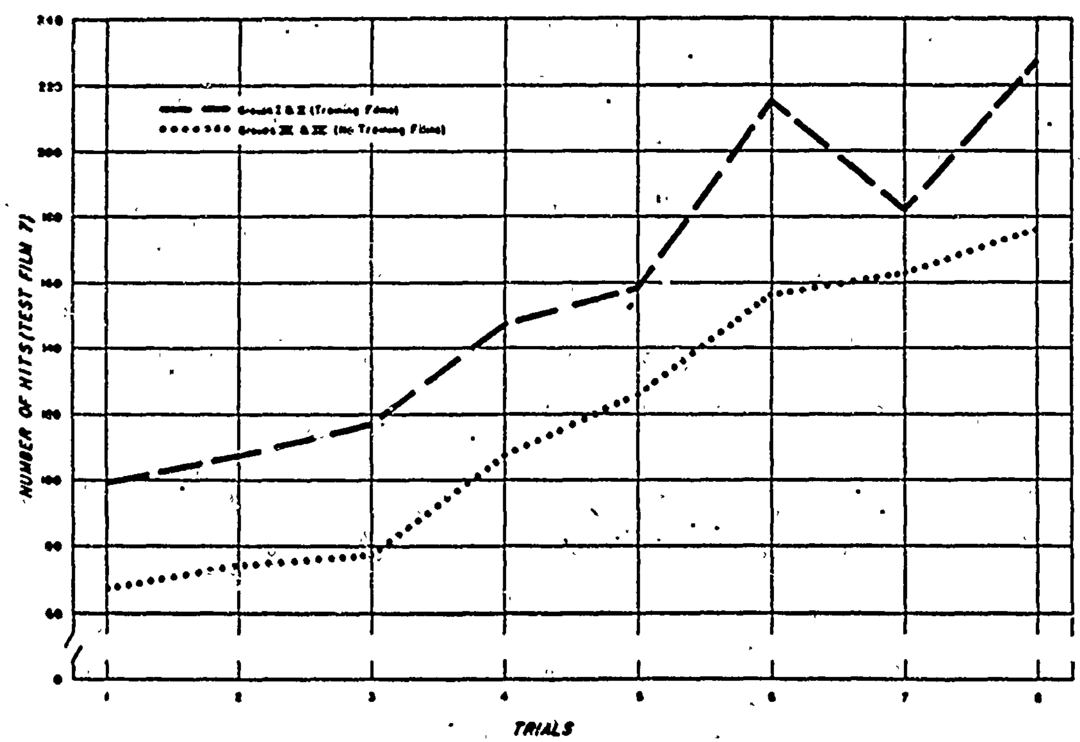


Fig. 9.9—Course of proficiency on Waller Trainer for students who were shown training films and for students who were not shown training films (N=32, Laredo, July '45)

States Navy. The original purpose of the unit was to provide a small, compact, and portable practice device for maintaining the proficiency of gunners while on board ship. After adoption and modification by the Army Air Forces, it was given the official catalogue name, E–14, but in use retained the traditional name, "Jam-Handy."

Description.—Although the trainer underwent minor and major modifications from time to time, it may be described as follows:

The device utilized two synchronized 16 mm. projectors situated approximately 12 feet from a screen measuring 12 feet by 12 feet. One of these projected motion pictures carefully designed to simulate the scene presented to a gunner by a fighter airplane attacking his bomber. Not only the attacking fighter, but also appropriate parts of the bomber appeared on the screen. The second projector, synchronized with the first, projected a spot of polarized light upon the screen at the correct point of aim for each part of the attacks shown. Situated in front of, and somewhat below, the level of the projectors was a sighting station usually mounting a model of a hand-held or free-swinging gun. The student operating this gun might be required to wear polaroid glasses which prevented his seeing the correct point of aim which appeared on the screen. His task was to maintain the correct point of aim without this aid. The instructor, however, could see both the correct point of aim and the student's point of aim, which appeared as a spot of light on the screen. The classroom provided space for as many as 10 students, of whom all but one were necessarily spectators at any one time.

In testing situations, the gunner always wore polaroid glasses. The instructor was furnished with a score sheet on which were printed standard-size ring sights similar to those projected on the screen. The first time the student's point of aim appeared during any attack was considered the first burst of fire. The instructor observed the point where the first burst struck the screen and made a mark on his printed ring sight representing the gunner's point of aim in relation to the true point of aim as shown by the center of the projected ring sight. In scoring, a plexiglass template, containing 10 concentric circles, the largest of which was equal to the diameter of the largest circle in the ring sight on the instructor's score sheet, was used. The template was laid over the score sheet, and the student was given a score from 0 to 10 depending upon the nearness to the center of the ring sight of his first burst as indicated by the instructor's mark. First bursts falling directly in the center of the ring sight were given a score of 10, and those falling within the ring sight but not in the center were given scores ranging from nine down to one, depending upon

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their distance from the center. First bursts falling outside the ring sight were given scores of zero.

From the standpoint of sound teaching procedure, the Jam-Handy possessed several highly desirable characteristics. These may be summarized as follows: The trainer made possible standardization of instruction wherever used. It was possible to design films for the trainer in which the sequence of the attacks might be controlled so that the student could fire at attacks which became progressively more difficult throughout the course of instruction. In this way the student faced a task equal to his ability, and could more easily acquire proficiency at the more difficult levels. It was possible to provide periodic reviews of training and to organize the material into a schedule optimum for learning. It was possible for the trained instructor to train and coach his students at all times. By use of the gun projection lights and the projected ring sights the student could have immediate knowledge of the success or failure of his firing.

Early investigations.—The earliest investigations were primarily concerned with improving the reliability of the scoring procedures. As an example, one scoring procedure in use in 1943 required that the instructor rate the student's performance in terms of a number of errors, such as, "fires too soon," (before the plane comes into effective range); another was, "fires too late," (waits too long); others were "doesn't fire enough bursts," "fires too many bursts," "too long bursts," or "too short bursts." For each such criticism the instructor deducted a certain number of points from the possible total score of 100 which the student might attain. In addition to such a rating as mentioned, the instructor made three additional general evaluations of the student's performance in terms of handling of gun, of "aptitude," and of "behavior." It can readily be seen that rapid ratings on such as the above might have low reliability. An early report described this scoring system and pointed out its weaknesses.[12] No data were given on the evaluation of the scoring system.

It was at this time that the scoring system described earlier was conceived; shortly thereafter it was put into effect experimentally at Buckingham, where it was evaluated statistically and found to be quite satisfactory when properly used. For example, in late 1943 an experimental test was made on the E-14 Trainer using the first 10 attacks of the film known as "Review on Quarter Attacks." [13] An analysis of 250 complete records revealed the following reliability coefficients (scores on odd-num-

[12] This analysis was made by Maj. Roger W. Russell.

[13] Lt. Arthur L. Irion supervised this study.

bered attacks vs. scores on even-numbered attacks, corrected by Spearman-Brown Formula):

1. The reliability of first-burst score was 0.82.
2. The reliability of third-burst score was 0.83.
3. The reliability of first plus third-burst score was 0.91.

These reliabilities were among the highest ever attained for performance on any criterion of gunnery proficiency. The following conditions prevailed at the time the experimental observations were made: The scorers had been well-trained previously in their tasks, and were motivated to do a careful job. Each student was tested according to a prearranged plan, and on exactly the same attacks as every other student. Each student was scored on the first and third bursts of these attacks. An officer was present at all times supervising the testing.

Thus, with the exercise of proper care it was possible to obtain a satisfactorily reliable score while using a subjectively based scoring system. It was this scoring system that was subsequently adopted for use throughout all gunnery schools and made mandatory in the directives which prescribed the manner in which flexible gunnery training would be conducted.

Mechanical scoring modifications.—Although the template scoring system described above was kept in continuous use throughout the history of the E–14 Trainer, several devices were produced from time to time which attempted to provide a mechanical scoring system for the trainer, eliminating the role of the instructor as a scorer.

The Infrared Scorer.—One mechanical scoring device was developed for the Navy and was known as the 3A–20A. In this device the projector which ordinarily projected the correct point of aim contained a film which projected a spot of infrared light 2 inches in diameter on the screen at the correct point of aim. With the infrared filter in front of the projector, the student could not see the correct point of aim. The gun operated by the student contained a photo-electric cell which, when the gun was pointed at the correct point of aim, was activated by the infrared light reflected from the screen; a circuit was then closed which allowed an electrical counter to record "hits." It was then possible to compare the number of hits recorded with the number of shots also automatically recorded whenever the student pressed his trigger, and thus to arrive at a percent hit score. The proof section of the Research Division conducted a series of tests using gunnery school students, and reliability coefficients for the scores were computed from the data obtained. Although neither the raw data nor the computations made from them is currently available, it is known that the original infrared scoring system was found

to have unsatisfactory reliability for use as a measure of gunner's proficiency on the E-14 Trainer. The principal source of difficulty seemed to be in the sensitivity of the recording device to fluctuations in line voltage. Subsequently, a second model of the same device known as the 3A-20B was produced and procured on a loan basis from the Navy. Some further experimental observations were made which revealed the device to be considerably improved over the original model, but nevertheless, still subject to variations in line voltage which seriously disrupted the reliability of the scores obtained.

Finally, a third model, 3A-20C, was received and tested at Laredo.[14] Thirty graduate gunners fired at the 22 attacks of a test film once on each of 3 consecutive days, and the scores for each attack were recorded from the infrared scorer. Reliability coefficients based on hits obtained and on percent of hits obtained were computed. These are reported in table 9.10.

TABLE 9.10.—*Reliability of scores obtained from infrared scorer, model 3A-20C: Means, standard deviations, number of cases, and inter- and intratrial reliability coefficients in terms of hits and percent of hits obtained (Laredo, June 1945)*

Trial	Hits				Trials	Hits		Percent hits	
	N	M	SD	r^1		N	r^2	N	r^2
1	30	454	128.5	0.63	1 vs 2	30	0.17	30	0.05
2	30	532	103.1	.60	1 vs 3	24	.08	24	.15
3	24	437	97.6	.71	2 vs 3	24	.14	24	.17

[1] Uncorrected product-moment correlation between 11 odd-numbered and 11 even-numbered attacks of each trial. All r's significant at the 1 percent level.
[2] Not corrected.

Although the intratrial reliability approached adequacy, coefficients between trials showed that day-to-day scores had very little in common. Thus, since the scores did not seem to permit meaningful comparisons of individual or group scores from day to day, its adoption in place of the subjective system described above was not recommended.

The ISCO Scorer.—Shortly before testing the 3A-20C, another device, known as the ISCO (Industrial Specialties Co.) Scorer, had been thoroughly tested by the Central School. Arrangements had been made to procure the ISCO scorers in considerable quantity, and it was recommended that the 3A-20 scorers be dropped from further consideration.

Description of the ISCO Scorer.—The ISCO scoring device consisted essentially of the following:

[14] Lt. Herbert D. Werwath was project officer for this study. Tests were conducted and data analyzed by Cpl. Walter Cohen.

1. A special projector for drawing 35mm. film strips continuously through two apertures, one aperture in the front, the other in the rear of the projector. This projector moved the film in synchronization with the standard 16mm. projector, but at a greatly reduced speed. This projector replaced the original E–14 projector used to project the correct point of aim on the screen.

2. Two sets of specially prepared 35mm. film strips. One set was for the front projection aperture, and the other set was for the rear aperture. Each set consisted of two strips of film. One strip had photographed on it a series of curves representing the vertical components of the point of aim for the attacks, and ran through the projection aperture horizontally. The other strip of each set had curves which contained only the horizontal components of the point of aim, and ran through the projection aperture vertically. When the two strips of a set were drawn across the same aperture at right angles, the transparent curves intersected each other at a point which, as the resultant of the horizontal and vertical curves, represented the correct point of aim. This correct point of aim was projected from the front end of the projector to the screen and also from the rear end into the lens of the scanning tube.

3. The scanning tube was mounted at the rear of the projector and was mechanically linked to the gun by a system of rods and gears so that it exactly duplicated the angular movements of the gun. Thus, when the gun was aimed at the correct point of aim on the projection screen the scanning tube was also aimed at the correct point of aim coming from the rear of the projector. When this alignment was achieved by correct aiming of the gun, the scanning tube passed the full illumination of the 500 watt projection lamp into the photocell.

4. The scoring system consisted of two counter dials, each of which recorded at a rate of 550 rounds per minute. The shot counter was activated whenever the student depressed his triggers, and the hit counter whenever the gunner had his trigger depressed and also was pointing the gun at the correct point of aim.

Test of the ISCO Scorer.—In the evaluation study [15] an attempt was made to get at the reliability and stability of the scores obtained with the ISCO Scorer.

One hundred and one basic gunnery students, all having completed approximately 8 hours of training on the E–14 Trainer, served as subjects. The special testing films supplied by the Industrial Specialties Company consisted of a series of tail cone

[15] The project officer for this study was Lt. Herbert D. Horwath, assisted by Cpl. Walter Cohen.

attacks presented in random order. It was not feasible to give exactly the same test to each student. However, since all attacks were from the tail cone, it appeared likely that most of the students would fire at equivalent attacks. After each attack, the experimenter recorded the scores obtained by the gunner.

An analysis of the results of this study, presented in table 9.11, indicated the scoring device to be fairly consistent during the firing of a series of attacks. One of the factors that appeared to be lowering the reliability was an excess of fly-through attacks in either odd or even numbered attacks; fly-through attacks were particularly difficult to track and aim at properly. Twelve cases

TABLE 9.11—*Means, standard deviations, and reliability coefficients obtained by using the ISCO E-14 scorer on a single trial of 10 attacks. (Laredo, 4th quarter, 1944)*

Type of score	N	M	SD	r	r (corrected)[1]
Percent hits	101	26.29	13.29	0.58	0.73
Hits	101	273.85	153.83	.63	.78
Percent hits (excess fly-through attacks removed).	89	26.01	13.81	.66	.80
Hits (excess fly-through attacks removed)	89	269.80	157.71	.69	.82

[1] Spearman-Brown formula.

in which there was a minimum of two fly-through attacks in excess for either the odd or even attacks were eliminated. After the data from these 12 cases were removed, the remainder yielded an odd-even attack reliability of 0.80 (corrected by Spearman-Brown formula) for percent hits and 0.82 (corrected) for hits.

To obtain information on the consistency of the machine over a period of time, means for the men tested during each of the 8 days were compared. These means, shown in table 9.12, indicated variations greater than chance would account for (see analysis of variance in table 9.13).

TABLE 9.12.—*Daily means and standard deviations obtained on ISCO E-14 scorer by subjects tested on different days (Laredo, 4th quarter, 1944)*

Day	N	Mean hits (10 attacks)	SD
1	13	229	113.54
2	10	154	141.11
3	14	249	116.94
4	9	333	184.51
5	22	216	63.43
6	14	385	183.30
7	4	266	82.20
8	15	364	155.10

Even when the factor of film differences, as represented by the number of fly-through attacks, was examined, it was noted that

difficulty of attacks was equally distributed over the different days, and that no drop in means could be attributed to an excess of fly-through attacks.

TABLE 9.13.—*Analysis of variance for daily variations in scores obtained on ISCO scorer (Laredo, 4th quarter, 1944)*

	df	Sum of squares	Variance
Between days	7	581,362.82	83,051.83
Within days	93	1,810,919.24	19,472.24
Total	100	2,392,282.06	

F-ratio: 4.265. F-ratio required for significance at 1 percent level: 2.8.

As a result of the test conducted, a number of recommendations were made for modifications in the device which would possibly minimize the variations in score from day to day and also allow the device to be used with other than the hand-held type of gun. Some time later plans were produced for connecting the ISCO Scorer to turrets to be installed in E–14 Trainers, and also plans for improving the scoring device as used with the hand-held guns. A few months before the end of the war it was decided to procure the ISCO scoring device as modified according to recommendations from the Central School for use throughout the gunnery program. However, with the ending of the war the contract was cancelled.

Use of E–14 Trainer as criterion.—Because E–14 Trainer scores could be obtained with fairly high reliability under carefully supervised conditions, the trainer was frequently used as a criterion of gunnery proficiency, both in the evaluation of training devices and in an effort late in 1943 to develop a battery of selection tests for flexible gunners. An example of the use of the E–14 as a criterion in evaluation of training devices is seen in the section of this chapter where an evaluation of the DeVry Panoramic Trainer is described.

As part of a project (see chapter 6) directed toward the development of the battery of aptitude tests for gunners, a number of the tests used in the selection of aviation cadets, together with some tests developed specifically for gunners, were administered to a class at Buckingham, and correlations with the E–14 Trainer were obtained. Scores on the E–14 Trainer were obtained by the reliable method described on page 9.19 and correlated with the tests listed in table 9.14.

The correlations shown in table 9.14 are all low, the highest being 0.12 for the electrical maze part of the Aviation Cadet Qualifying Examination. An observation of the psychological functions used on the Jam-Handy led to the conclusion that three

factors were predominatingly involved, the perceptual one of judging the position and line of apparent motion of the attacking fighter, the informational one of knowing necessary leads, and the psychomotor one of tracking the fighter. In view of this, higher correlations were expected with tests of perception. It may have been that the psychomotor factor far outweighed the perceptual factor in attaining success on this trainer as measured in this study.

TABLE 9.14.—*Means, standard deviations, and product moment correlations of experimental battery scores on the Jam-Handy trainer (class 44-4, Buckingham, first quarter, 1944)*

Test	Pearson r with Jam-Handy	N[1]	M	SD
1. Army general classification	−0.047	277	110.27	14.29
2. Mechanical aptitude	.068	224	106.42	14.84
3. Plane formation	−.075	277	169.07	24.15
4. Angular judgment	.005	277	27.61	8.22
5. Aviation cadet:				
Qualifying AC12J (total score)	.049	277	158.83	27.18
Part I. Electrical Maze	.124	222	17.95	5.14
Part II. Gottschaldt figures	−.038	222	27.33	8.19
Part III. Line, length, point distance	.044	222	41.57	10.70
Part IV. Judgment	.039	222	13.65	3.13
Part V. Flying information	.030	222	22.14	5.85
Part VI. Mechanical principles	.065	222	83.02	9.45
6. Gunnery aptitude:				
Test AC30A (total score)	−.059	277	126.47	25.59
Part I. Gunnery interest	−.076	222	18.42	4.67
Part II. Plane memory	−.049	222	21.42	7.65
Part III. Gunnery learning	−.041	222	27.99	6.38
Part IV. Mechanical principles	.012	222	17.72	4.52
Part V. Mathematics	−.027	222	15.49	4.41
Part VI. Speed of identification	−.016	222	26.80	7.56
7. Biographical data blank	.080	277	7.87	3.18
8. Estimation of velocity	−.005	277	22.74	5.18
9. Identification of velocity	−.008	277	80.13	5.65
10. Estimation of relative velocity	.012	277	29.19	5.72
11. Opinion poll	−.095	208	283.73	30.96
12. Technical vocabulary	.023	152	105.36	16.10

[1] N for the mean and standard deviation; for the r it may sometimes be a little smaller.

Table 9.15 shows the intercorrelations of Jam-Handy with the other criteria. None of the criteria correlated significantly with Jam-Handy.

TABLE 9.15.—*Means, standard deviations, and intercorrelations of criteria for experimental battery (N=246–277, class 44-4, Buckingham, first quarter, 1944)*

Criterion	1	2	3	4	5	6	M	SD
1. Gunnery final, form C	-------	0.108	0.107	0.062	0.055	0.028	126.3	8.37
2. Skeet shooting	0.108	-------	.526	.158	.061	.080	61.8	10.76
3. Skeet with moving base	.107	.526	-------	.161	.108	−.041	53.6	9.17
4. Turret-mounted shotguns	.062	.158	.161	-------	.165	.071	64.5	8.77
5. Jeep-pulled targets; machine guns.	.055	.061	.108	.165	-------	.023	23.8	5.12
6. Jam-Handy	.028	.080	−.041	.071	.023	-------	4.2	1.26

Some time before the investigation just referred to was undertaken, a printed examination known as AC30A had been de-

veloped as an aptitude test for flexible gunners; as part of the validation procedures for this test, correlation coefficients with the Jam-Handy trainer were determined. Again the correlation coefficients with the Jam-Handy trainer were determined. Again the correlation of the total test and its parts with the Jam-Handy scores appeared to be very low. They are reported in detail in chapter 6.

AAFSAT Synthetic Trainer

As the program for the training of B–29 gunners got under way, the Strategic Bombardment Section of the Army Air Forces Board came out with a synthetic trainer for B–29 gunnery based on the E–14, or Jam-Handy, trainer. Research personnel were sent to Orlando where the trainer was located to conduct an experimental investigation of the trainer.

Description.—The trainer that the Board had developed was a standard E–14 Trainer with B–29 pedestal and ring sighting stations installed. It was frequently referred to as a dual projection trainer because the combining glass in the sighting head had been replaced by a mirror which projected an image of the sight reticle onto the screen. As the attacks developed on the screen it was the gunner's job to track and frame the oncoming plane. The instructor observed performance, and when he decided that the gunner was properly tracking the plane (defined as having the center of the sight reticle on the image of the fighter), and framing it (having the circle of dots approximately the diameter of the plane's wingspan), he would close a switch which would cause a counter to register "hits," opening it when the student got "off" the target. In the observations summarized here three observers were used in the scoring. The method of combining their observations is not clear from the report, which reads "One member of the experimental staff read the B–29 Synthetic Trainer clocks which were used to record the number of rounds fired and the length of time the observers individually held down their keys, expressed in terms of rounds fired during that time." It is presumed that clocks recorded a number representing rounds fired each time the subject pressed the trigger. Since the method of projecting the reticle onto the screen involved removing the gyroscopes from the sights, it is possible that the gunner's task was changed significantly by the resulting disturbance of the inertia and balance of the elevation system.

Experimental procedure.—The observations at Orlando [16] were undertaken to answer the following questions:

[16] The project officer for this study was Capt. Alfred C. Jensen, assisted by Lt. Clarence W. Willey and Sgt. Carl Martens.

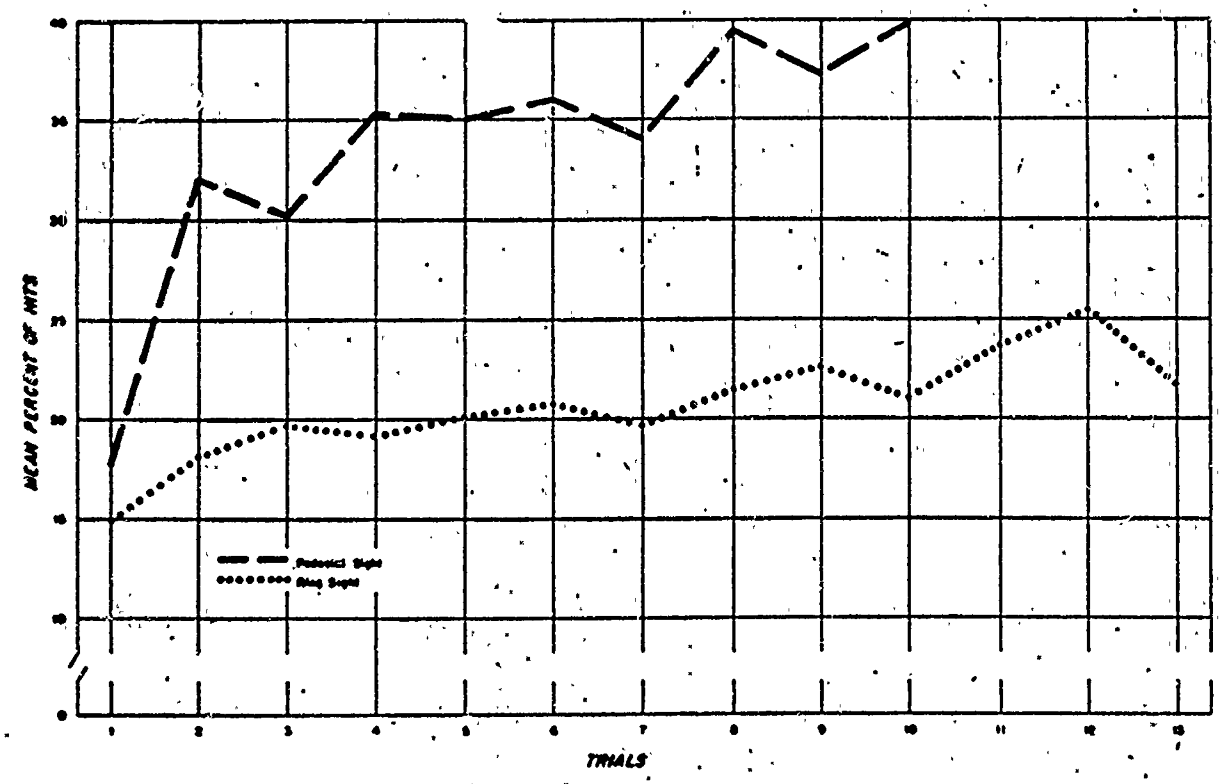

Fig. 9.10 – Learning on the AAFSAT B-29 Synthetic Trainer: mean percent of hits on Pedestal and Ring sighting stations (N=42, Orlando, 3rd quarter, '44)

1. How long should a student operate a sighting station on the synthetic trainer during one period?
2. What is the optimum number of periods of instruction to schedule on any one day of the gunnery course?
3. How can the student learn most expeditiously to track and frame smoothly?
4. Do gunners differ basically in their ability to adapt themselves to B–29 gunnery training, and if so, how can naturally superior gunners be selected?
5. How much training is necessary to bring the student to a satisfactory level of ability in tracking, ranging, and in simultaneously tracking and ranging?
6. What is the place of the AAFSAT Synthetic Trainer in a course of instruction for B–29 gunners?

Forty-two gunners of unreported background and ability fired 10 trials, one trial daily, using the pedestal sighting station, and 13 trials daily using the ring sighting station. Each trial was of four minutes duration and consisted of 16 attacks of unreported duration and direction of origin.

Results.—The results of these trials, converted to percentage of hits, were used as the basis for determining the curve of learning for the pedestal and ring sighting stations, which are presented in figure 9.10. The data are given in table 9.16.

In another set of observations 5 bombardiers (group A), 10 ex-combat gunners (group B), 10 graduate gunners (group C), and 10 inexperienced (presumably naive or untrained) gunners (group D) fired 10 trials, 1 trial daily, using the pedestal sighting station. Each trial was of 4 minutes duration and included 16 attacks. The results of these trials, converted to percentage of hits, were used as a basis for determining learning curves by groups for the pedestal sighting station. These data are shown graphically in figure 9.11 and are given also in table 9.17.

TABLE 9.16.—*Learning on the AAFSAT B–29 synthetic trainer: Means and standard deviations of percent of hits scored by trials on ring and pedestal sighting stations (N=42, Orlando, July 1944)*

Trial	Pedestal station		Ring station	
	M	SD	M	SD
1	17.72	7.81	14.98	4.73
2	32.07	11.19	18.01	5.35
3	30.20	12.29	19.61	7.59
4	35.29	9.43	18.98	4.92
5	34.99	8.77	20.07	5.81
6	36.05	10.19	20.60	7.34
7	34.03	8.51	19.60	6.38
8	39.49	9.98	21.29	6.07
9	37.28	11.46	22.55	6.65
10	39.39	7.57	20.87	7.02
11			23.48	5.84
12			25.37	5.56
13			21.46	7.80

The same four groups of subjects completed 13 daily trials from the ring station, trials being identical with those in other situations cited. The results were converted to percentage of

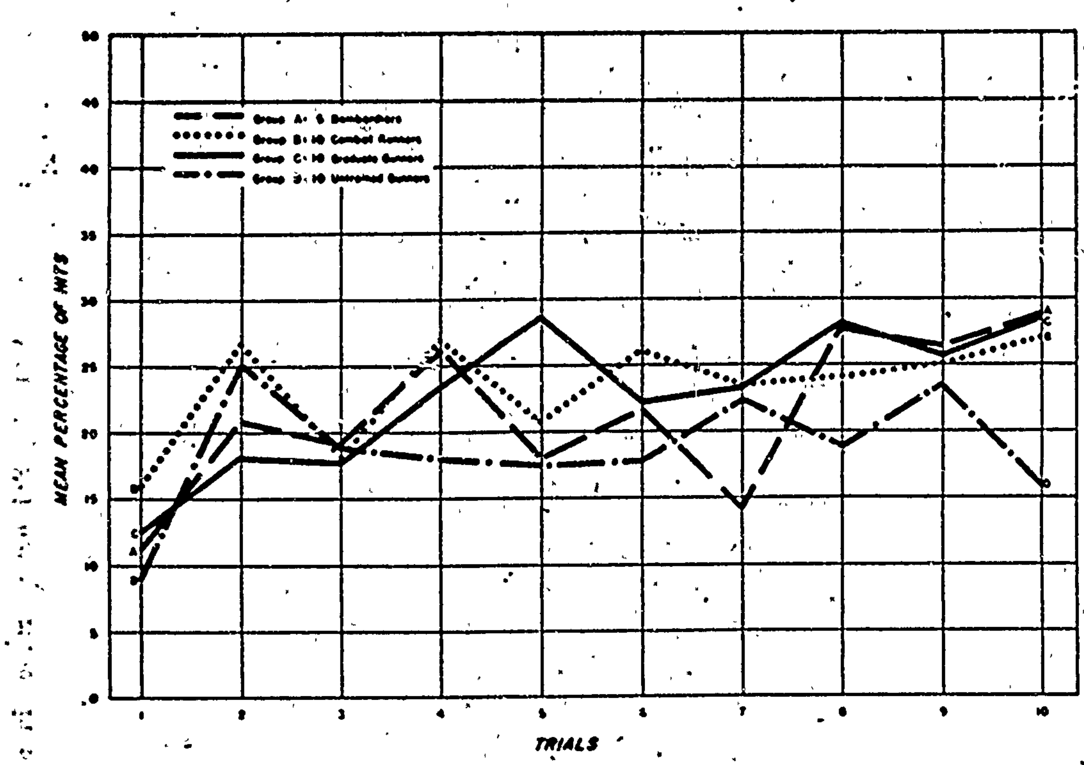

Fig 9.11—Learning on the AAFSAT B-29 Synthetic Trainer: mean percentage of hits made on pedestal sighting station by 4 groups of subjects (Orlando, 2nd quarter, '44)

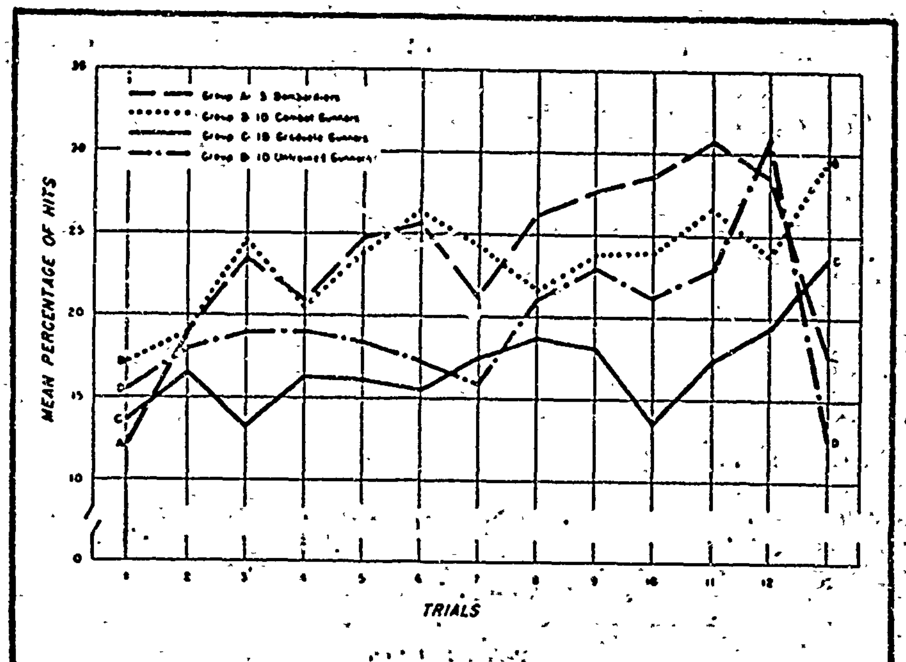

Fig. 9.12 – Learning on the AAFSAT B-29 Synthetic Trainer: mean percentage of hits made on ring sighting station by 4 groups of subjects (Orlando, 3rd quarter, '43)

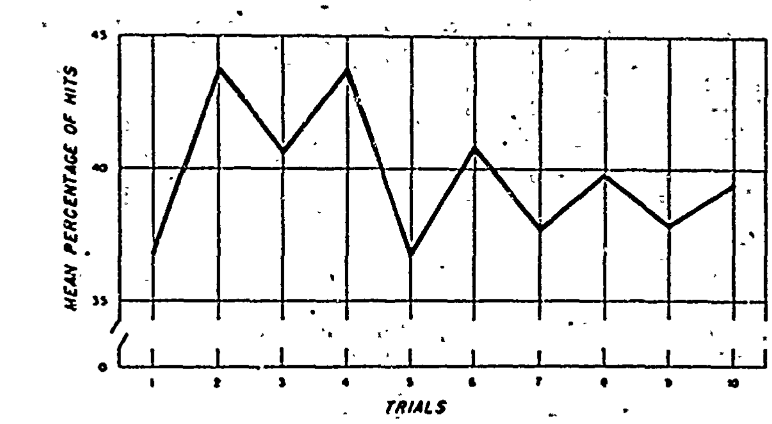

Fig. 9.13 – Influence of fatigue on performance on the AAFSAT B-29 Synthetic Trainer: mean percentage of hits on 10 consecutive trials (N=10, Orlando, 3rd quarter, '44)

hits and plotted as a learning curve by groups for the ring station. The data are shown in table 9.17 and are graphically represented in figure 9.12.

Ten gunners, selected for their superior firing records on the trainer, fired 44 minutes consecutively from the ring sighting station in an effort to reveal symptoms of fatigue and derive an indication of the optimum amount of time that should be devoted to the trainer in a single practice period. The results of this practice, converted to percentage of hits, are plotted in figure 9.13 and shown in table 9.18.

According to data shown in table 9.18, there was no serious decline in efficiency throughout the entire work period.

The statistical results of the observations reported above do not, in themselves, furnish satisfactory answers to any of the original questions, primarily because of the low reliability of daily scores as indicated by an average inter-day correlation of 0.29 for the percent of hit score on the pedestal sight and .51 for the same score on the ring station. See table 9.19.

TABLE 9.17.—*Learning on the AAFSAT B–29 synthetic trainer: Mean percent of hits scored by trials on pedestal and ring sighting stations (four groups of subjects: A, 5 bombardiers; B, 10 combat gunners; C, 10 graduate gunners; D, 10 untrained gunners, July, 1944)*

Trial	Pedestal station				Ring station			
	A	B	C	D	A	B	C	D
1	11.2	15.8	12.8	9.1	12.2	17.2	13.6	15.5
2	20.7	26.5	18.0	25.0	19.0	19.0	15.5	18.0
3	19.1	18.1	17.8	19.0	23.5	24.6	13.3	19.0
4	26.2	26.9	23.4	18.0	20.9	[illegible]	16.3	19.1
5	18.0	20.8	28.7	17.5	24.8	[illegible]	16.2	18.5
6	21.7	26.1	22.3	17.8	25.7	26.4	15.5	17.3
7	14.2	23.5	23.2	22.2	21.3	24.3	17.5	16.0
8	27.6	24.0	28.2	18.8	26.2	21.5	[illegible]	21.1
9	26.4	25.0	25.7	23.5	27.7	23.8	[illegible]	23.0
10	28.9	27.0	28.6	16.0	28.7	24.0	13.6	21.2
11	------	------	------	------	30.8	26.6	17.4	22.9
12	------	------	------	------	28.5	23.7	19.4	31.0
13	------	------	------	------	17.8	29.6	23.6	[illegible]

TABLE 9.18.—*Influence of fatigue on performance on the AAFSAT B–29 synthetic trainer: Mean percent of hits scored on 10 consecutive trials (N=10, Orlando, July 1944)*

Trial	Mean percent of hits	Trial	Mean percent of hits
1	36.8	6	40.8
2	43.7	7	37.7
3	40.6	8	39.8
4	43.7	9	37.9
5	36.7	10	39.4

TABLE 9.19.—*Reliability of AAFSAT B-29 synthetic trainer: Intercorrelations of daily scores in terms of percent hits made from pedestal and ring sighting stations, (N=42, Orlando, third quarter, 1944)*

Days	Pedestal[1]	Ring[2]	Line Number
1 and 2	0.47	0.42	1
2 and 3	.40	.37	2
3 and 4	.26	.39	3
4 and 5	.30	.64	4
5 and 6	.47	.68	5
6 and 7	.34	.49	6
7 and 8	.03	.34	7
8 and 9	.07	.56	8
9 and 10	.16	.68	9
10 and 11		.80	10
11 and 12		.46	11
12 and 13		-.33	12
5, 6, 7 and 8, 9, 10	.40	.69	13
8, 9, 10 and 11, 12, 13		.74	14
1-5 and 6-10	.43	.82	15

[1] Average for pedestal sight, lines 1-9, =.29.
[2] Average for ring sight, lines 1-2, =.51

Discussion of results.—It will be noted that the reliabilities obtained for the ring station became satisfactory when scores for 3 and 5 days were combined.

Data are reported in table 9.20 which suggest that observer agreement in the scoring situation ran quite high, but the nature of these data is not sufficiently known to allow further elaboration.

The fact that the ring station was approximately twice as far from the screen as the pedestal station precluded direct comparisons of data obtained on performance at the two stations.

Although the statistics resulting from these observations were not very fruitful, considerable insight into the operation of the trainer and into problems related to it was gained, which enabled the observers to give at least partial answers to the questions posed at the beginning of the investigation.

1. *How long should a student operate a sighting station on the trainer continuously during one period?*—In the fatigue experiment, 10 gunners operated the ring station continuously for 44

TABLE 9.20.—*Reliability of 18 observers in scoring 160 attacks on the AAFSAT B-29 synthetic trainer, (Orlando, third quarter, 1944)*

Observers correlated 1	vs. 2	M_1	SD_1	M_2	SD_2	r_{12}
Beaton	Clapp	20.09	14.27	20.19	19.67	0.77
Surbaugh	Sullivan	28.01	17.38	26.31	20.72	.87
Trotta	Taylor	40.63	25.02	31.22	22.68	.82
Terry	McGinnis	24.22	15.59	31.91	28.21	.71
Mayer	Manor	26.41	14.54	31.56	15.31	.58
Anderson	Collins	13.41	11.31	13.30	11.99	.79
Flynn	Gregory	19.38	16.77	15.03	13.70	.84
Kurman	Adams	33.84	22.67	34.19	22.33	.85
Garrison	Phillips	18.19	13.07	20.31	14.08	.77

minutes. The results can be noted in table 9.18 and figure 9.13. There was no serious general decline in efficiency during the period of firing. It was the general belief of the subjects, however, that they experienced slight muscular fatigue after approximately 20 minutes of continuous operation, and that some eye fatigue was apparent at the end of 44 minutes of practice. Since no gunnery school schedule was likely to permit as long a period of uninterrupted practice, there was no concern that a practice session might be continued to the point where fatigue would seriously reduce training efficiency, providing sufficient motivation was maintained.

2. *What is the optimum number of periods of instruction to schedule on any one day of the gunnery course?*—In light of the preceding paragraph there would be no objection to scheduling a number of periods of instruction on any 1 day of the gunnery course. Within the limits of such scheduling ordinarily encountered in gunnery school programs, fatigue of the student was not likely to prove a serious factor, if motivation were maintained.

3. *How can the student learn most expeditiously to track and range smoothly?*—It must be expected that some students will show a high degree of skill as soon as initial orientation to the sighting system is accomplished, while others will exhibit little proficiency no matter how long their training is continued. Others will show varying degrees of sudden or gradual improvement. Efficiency of learning with this trainer, as with any other, depended on providing a good training situation and maintaining strong motivation. The subjects manifested a very satisfactory degree of motivation throughout the entire series of tests. This motivation probably resulted from a confidence in the value of the trainer which was shared by the subjects and the experimental and instructional staff, a constant effort of the instructors to improve performance, and the availability of quantitative scores which were accepted by the subjects as adequate in spite of the recognized subjective element in the observers' judgments of performance. Duplication or improvement of these conditions in regular gunnery school instruction on the B–29 E–14 Trainer was believed able to provide the maximum possible degree of progress in the acquisition of tracking and ranging skill.

4. *Do gunners differ basically in their ability to adapt themselves to B–29 gunnery training, and if this is true, by what means can the naturally superior gunners be selected?*—The first part of this question has been answered affirmatively under 3 immediately above. The naturally superior gunners might have been selected by trying them out in actual operation of the sighting stations of the trainer. About 5 trials of 4 minutes each were believed ade-

quate to indicate the subsequent general level of performance; however, final judgment on this point was not justified by the data derived from the experiment.

5. *How much training is necessary to bring the gunnery student to a satisfactory level of ability in tracking, in ranging, and in simultaneously tracking and ranging?*—In the light of results available, the experimental staff believed 120 minutes of actual operation by each student represented a practical and conservative standard for gunnery school use of the trainer.

6. *What is the place of the AAFSAT Strategic Bombardment Section Synthetic Trainer in a course of instruction for B–29 gunners?*—It was recommended that the B–29 E–14 Trainer should be considered as a possible means of giving ground training to B–29 gunners.

The DeVry Panoramic Trainer

An example of the findings of psychological research resulting in the rejection of a proposed gunnery training device is seen in the story of the DeVry Panoramic Trainer (3A–11–Mark I and 3A–11–Mark II).

Description.—This trainer was a device composed of a hydraulically operated turret mechanism upon which was mounted a motion picture projector unit. This unit projected on a stereoscopic screen (two ground glass screens approximately 2″ x 2½″ in size) photographs of various pursuit curve attacks similar to those found on Jam-Handy (E–14) films. The student sat in the turret with his face against a view-piece, containing a stereoscopic lens arrangement, and viewed the attacks as projected on the screen. By proper manipulation of the turret, a ring sight, cast on the screen from a second projector, could be moved to the proper point of aim with reference to the attacking plane. When the student aimed properly in both azimuth and elevation, two slits in attached scanning bars became aligned, allowing light to reach photo-electric cells. The photo-electrically activated scoring mechanism recorded the number of shots fired and the hits obtained. The student was immediately informed of his hits by a red light flashing on the screen. The machine contained enough film in a continuous loop for a 4¾-minute run presenting 14 attacks. At the end of each run the device automatically stopped and could be started immediately by pressing a button.

Experimental evaluation I.—A preliminary evaluation of the Mark I version was conducted at Buckingham in November of 1943.[17] For lack of a more suitable criterion the E–14 Trainer

[17] The project officer for this study was Capt. Theodore R. Vallance. He was assisted by Sgt. Rudolph Goodman.

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was chosen since it could be scored with satisfactory reliability.

Thirty students in their third week of gunnery training were obtained as subjects and given a pre-test on the E-14 Trainer using a film known as "Various Attacks," showing a cycle of 25 attacks coming from varying directions. E-14 Trainer personnel were informed of the nature of the test and carefuly instructed in the scoring of first bursts to assure a standard measure of performance. All subjects fired and were scored on the same attacks on both the pre-test and the post-test. The subjects were divided into two equal groups on the basis of pre-test performance. The control group continued with the regular gunnery course, which included instruction on the E-14 Trainer. The experimental group, in addition to the regular training in the gunnery course on the E-14 Trainer, received 20 trials of 4¾ minutes each on the DeVry Trainer, 3 trials on the first day, 2 on each of the next 7 succeeding days, and 3 trials again on the ninth day. The same practice film was used throughout. Scores by trial and by day were recorded in terms of percent hits. On the tenth day both groups were post-tested on the "Various Attacks" film on the E-14 Trainer.

Results, Experiment I.—The data are presented in table 9.21 below.

TABLE 9.21.—*Means, standard deviations, difference and significance of difference in gains between control and experimental groups on initial and final tests on E-14 trainer (Buckingham, December 1943)*

	N	Pre-test		Post-test		Pre-post-test gain	Difference in gain	t
		M	SD	M	SD			
Experimental group	15	121.8	24.2	187.3	36.5	65.5	6.10	[1] 1.77
Control group	15	123.1	23.9	182.5	32.3	59.4		

[1] The difference in gains would occur by chance about 9 times in 100, and is not considered reliable.

With a t of 2.26 required for significance at the 5 percent level, it is clear that no significant differences were found in the mean gains of the two groups from the pre-test to the post-test. The absence of a difference may, it is true, have been due in part to the difference in the tasks: the E-14 was a hand-held, or free, gun situation, whereas the DeVry involved manipulation of a turret. Nevertheless, whatever the benefit to skill in judging deflections that may have accrued from practice on the DeVry, such benefit did not show up in the E-14 situation.

Some additional observations were made regarding the operation of the DeVry, which pointed out several practical objections

to the device: The continuous loop of film involved considerable maintenance. The light slits in the scoring mechanism were too small to permit a sufficient sample of successful shooting. The fluctuations in score due to fluctuations in line voltage were so great that differences in scores from student to student could not be relied upon as indicating differences in ability. The films supplied did not specify the speed of the bomber, which rendered the trainer useless for Position Firing training. Nor did they show any point of orientation on the gunner's airplane, necessary to determine angle-off and thus put Position Firing rules into effect. The fact that only the student could see his performance limited the instructional possibilities of the trainer.

On the basis of these findings and observations the recommendation of the psychologists that the trainer not be adopted for use in the Training Command was followed.

Modifications and later models.—This was not the end of the DeVry, however, for soon a modification kit was provided which eliminated the scoring difficulties, and included new films with orientation points so that the student could determine the angle-off of the attacking fighter. No tests were conducted of the trainer with the modifications included. Shortly after the modifications were made on the Mark I Trainer, a new model, the Mark II, appeared. This model embodied all the improvements of the modification kit and was in addition much more stable mechanically, involving very much less maintenance.

Experimental evaluation II.—An experiment was conducted in collaboration with the Department of Psychology of the School of Aviation Medicine which was designed to determine the influence of practice with the DeVry (Mark II) on gunnery proficiency as measured by the gun camera. The experiment had other purposes but only those related to the DeVry are described here.[18]

All subjects in this experiment were graduates of the Basic Gunnery School at Laredo, and had Army General Classification Test scores of 120 or better. The 16 men concerned with the DeVry had been trained in the operation of the Martin turret. On the first day of the experiment the subjects were pre-tested on the DeVry Mark II for about 15 minutes.

Each subject was given three carefully controlled gun camera missions in the Martin turret of a YB–40 airplane, (a modified B–17 equipped with both Martin and Sperry upper turrets), each mission consisting of 6 attacks by a P–40 airplane. Three attacks began at the 9 o'clock position and 3 at 3 o'clock; all were

[18] This project was conducted in collaboration with the School of Aviation Medicine, represented by Capt. Moncrieff H. Smith. Capt. Mason Haire and S/Sgt. Riner C. Payne represented the Research Division of CSFG.

flown on pursuit curves. Despite great precautions, conditions beyond the control of the experimenters resulted in many aborted attacks and hence incomplete missions. Gun camera films were developed overnight and were given a preliminary scoring next morning so that subjects could know the nature of their performance of the preceding day before the next mission that afternoon. The method of developing and scoring the gun camera film was by this time fairly highly developed and standardized, and is reported elsewhere in this chapter; suffice it at this point to say that reliability of scoring in this study was satisfactory.

After the 3 gunnery missions were completed the 16 subjects were given 4 trials daily on the DeVry Mark II for 12 days. Apparatus difficulties prevented each gunner from completing more than 44 trails; each trial consisted of 44 attacks.

Following practice on the DeVry Trainer the subjects were again given 3 gun camera missions of 6 attacks each using the same procedure as before. Table 9.22 summarizes the measures of the gunner's proficiency on the three gun camera missions before and after practice on the trainer.

TABLE 9.22.—*Gunnery proficiency on gun camera missions before and after practice on panoramic gunnery trainer: Means, standard deviations on pre-test and post-test, and difference and significance in circular errors, in mils (Laredo, 3d quarter, 1944)*

	N	Mission 1–3		Mission 4–6		Diff	SE_{diff}	t
		M	SD	M	SD			
Circular Error [1]	16	25.80	6.28	25.65	5.35	0.15	1.50	0.10

[1] For definition of circular error, see p. 222.

The data in table 9.22 indicated that there was no significant change in the gun camera performance of the subjects as a consequence of the intensive training on the DeVry Panoramic Trainer. However, these findings appeared not to be definitely against the DeVry, for, as pointed out elsewhere in the chapter, it is altogether possible that the subjects had reached their ceiling of gun camera proficiency long before receiving the benefits of the DeVry, making it unlikely that performance on the last 3 missions could have been raised by any means.

Rank-order correlations were computed between scores on the DeVry and scores on the gun camera. These indicated only very small relationships among the scores, suggesting that either the two tasks or the several scores had very little in common. This argued against the suggested use of the DeVry as a selection test for gunners. See table 9.23.

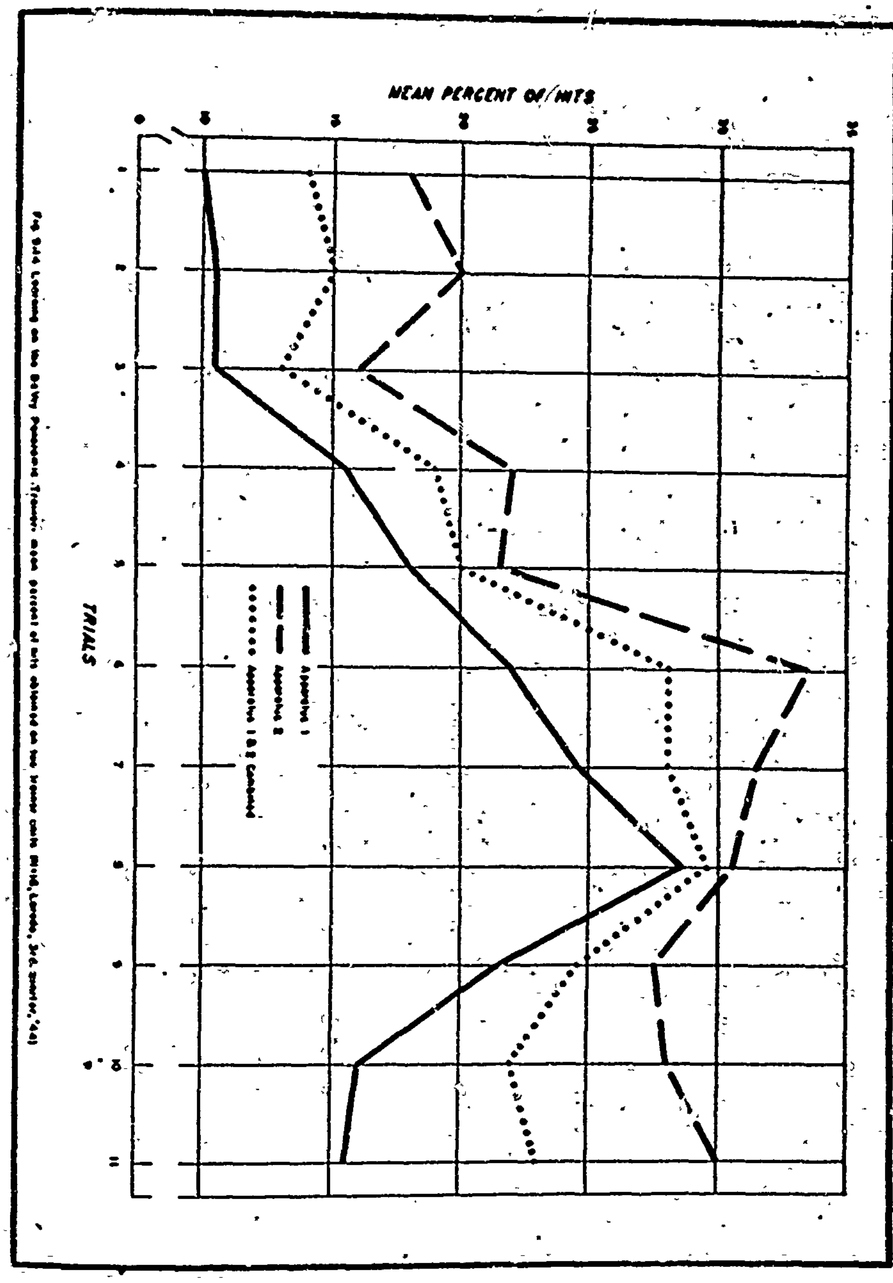
MEAN PERCENT OF HITS
TRIALS

Table 9.23.—*Rank order correlation between Martin gun camera scores (circular errors) and hit and percent hit scores on the DeVry panoramic trainer (N=16 Laredo 3d quarter, 1944)*

	Average circular error	
	Missions 1–3	Missions 1–6
DeVry hits	—0.22	—0.13
DeVry percent hits	0.10	0.13

Learning on the DeVry.—Observations made during the period of practice on the trainer revealed further information. Scores on the trainer are shown in figure 9.14, and indicate considerable improvement during the first 8 days of training. The decline during the last 3 days may have been due to decline in motivation of the subjects. The two trainers and the four films used in the training period showed considerable differences among themselves. Trials for each gunner were counterbalanced so that each gunner used each film in each of the two apparatuses equally often during the first eight days of training. This counter-balancing plan could not be followed during the last four days because of maintenance difficulties with apparatus No. 2. An analysis of variance in the trainer scores, shown in table 9.24, indicated that differences in scores due to the apparatus used accounted for most of the variance in the mean total scores for the entire training period. That is, differences between scores of the gunners could be almost entirely accounted for by the use of different films and

Table 9.24.—*Analysis of variance of percent hits scores, films 1 and 2, and films 3 and 4 grouped.—DeVry panoramic Trainer Mark II (Laredo, 3d quarter, 1944)*

Source of variation	df	Sum of squares	Mean square	F	F.05 [1]	F.01 [2]
Individual	15	44,409.98	2,960.67	1.99	2.41	3.52
Apparatus	1	43,108.14	43,108.14	29.02	4.54	8.68
Films	1	24,375.02	24,375.02	16.41	4.54	8.68
App x Film	1	1,000.14	1,000.14	1.49	4.54	8.68
Indiv x App	15	72,145.61	4,809.71	3.24	2.41	3.52
Indiv x Film	15	18,710.74	1,247.38	1.19	2.41	[illegible]
Error	15	22,285.61	1,485.71			
Total	63	226,035.28				

	Table of means		
	Films 1 and 2	Films 3 and 4	Average of 4 films
Apparatus 1	209.13	162.19	185.66
Apparatus 2	253.13	222.00	237.56
Average of 1 and 2	231.13	192.10	211.61

[1] F-ratios required for significance at 5 percent level.
[2] F-ratios required for significance at 1 percent level.

different training apparatuses rather than by differences in their individual abilities.

The weakness in the scoring mechanism made itself apparent during the training period. It was found to be very difficult to maintain uniform sensitivity of the photoelectric scoring system from day to day by the use of the calibration technique provided for the device.

Results and conclusions.—As a result of these findings it was recommended to higher headquarters that the trainer was "not yet adequate for general distribution as a training device or as a test of gunnery proficiency." As a result of this recommendation all developmental work on the device was cancelled.

SHOT GUN RANGES

Introduction

Shot gun ranges were used very early in the development of gunnery training, and persisted until the end of the war. They underwent various modifications designed to increase their similarity to gunnery methods in use in combat and to adapt them to new developments in sighting methods and in equipment. In spite of the differences between shot gun firing on the various ranges and the firing of machine guns in aerial combat, many gunnery officials attached definite importance to shot gun firing as part of the training of gunners. Nevertheless, various studies were carried out in an effort to discover the adequacy of these ranges.[19]

Skeet and Its Modifications

In the earliest days of the gunnery program, the well-known sport of skeet possessed two advantages as a gunnery trainer: first, the fact that it required the gunner to track and lead a moving target; and second, the fact that equipment and trained instructors were already available. These advantages of conventional skeet became of less importance as clearer conceptions of the gunner's problem were developed, and as other trainers were constructed. In the meantime, however, skeet had taken on various forms having somewhat greater face validity. Conventional skeet was no longer required after December 1943, and modified skeet was dropped in May of 1944.

Description of the Skeet Range.—In its original form, skeet was fired by using an unmodified 12-gauge shotgun, in accordance with

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[19] Studies of the reliability of the shot-gun ranges, unless otherwise specified, were carried out by Sgt. Alexander N. Levine. Studies of the learning curves, unless otherwise specified, were carried out by S/Sgt. Burton R. Wolin and Lt. William B. Schrader, under the direction of Capt. Lee O. Garber.

a standardized course of shots from each of eight positions of varying degrees of difficulty, at clay birds ejected by traps so as to follow a standardized flight course. The instructions given the gunner were designed only to permit him to attain the highest possible score in terms of number of birds shattered. A reliability for this type of score was found to be 0.84 (corrected by Spearman-Brown) for odd 25 vs. even 25 shots in a study done at Tyndall in 1942.[29] However, in the same report, questions were raised as to the extent to which skeet resembled the job of the gunner in combat.

A variety of relatively minor modifications of skeet developed early in response to experience with its use in training. Among other things, the procedure was varied by giving students slightly more practice on the more difficult positions, and by eliminating the eighth position, which required almost vertical shooting. Later, during the summer of 1944, shotguns provided with spade grips and mounted on swivels, to increase their similarity to hand-held machine guns, were introduced.

Learning on the Skeet Range.—In a study based on scores of 616 gunners in classes 44–31, 32, 33 at Laredo, a learning curve was obtained for skeet, thus modified. Since instructors were permitted to use 3 of the 25 rounds on each trial to give each individual gunner additional practice on positions which gave him greatest difficulty, the trials were not uniform. All gunners had fired one previous orientation trial. Results, presented in table 9.25 and shown graphically in figure 9.15, indicated that an upward trend in scores was apparent, but that the trend was relatively slight when measured in terms of birds shattered in a given trial.

TABLE 9.25.—*Learning curve data for skeet range: mean scores and percent hits for 5 successive trials of 25 rounds each (N=616, classes 44–31, 32, 33, Laredo, July-August, 1944)*

Trial	Mean score	Percent hits
1	15.4	61.6
2	15.6	[illegible]
3	15.7	62.8
4	15.9	63.6
5	16.5	66.0

The average gunner appeared to be learning relatively little on the skeet range. No formal investigation of the validity of conventional skeet or its simpler modifications was carried out. Instead, skeet was displaced by basic deflection firing, a close counterpart, on the basis of the judgment of experienced training per-

[29] This study was done by Lt. George J. Wischner and Sgt. Gerald Blum.

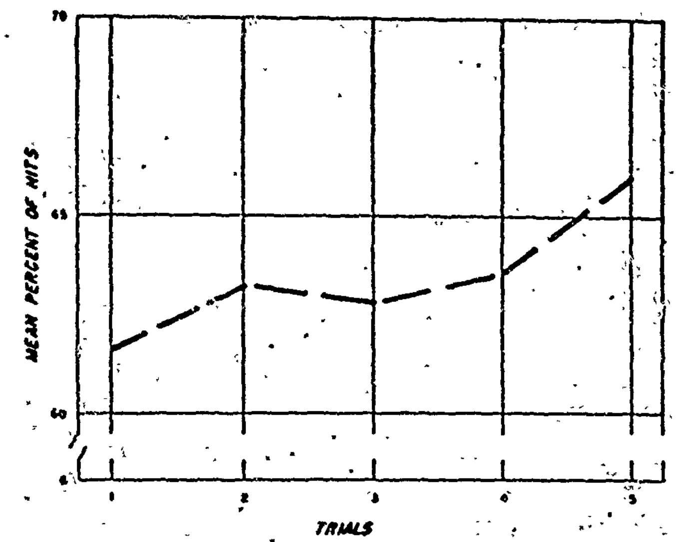


Fig. 9.15 Learning at the Skeet Range: mean percent of hits on 5 successive trials of 25 rounds each (N=616, Class 44-31, 32, 33, Laredo, July-Aug. '44)

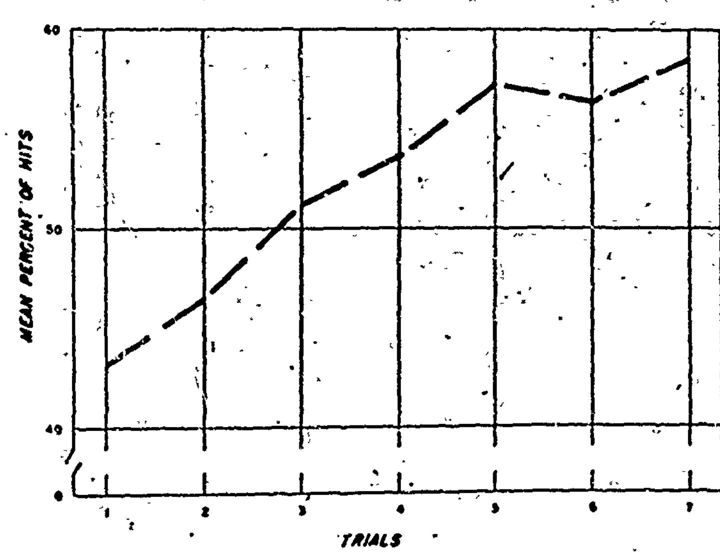


Fig. 9.16 Learning on the Basic Deflection Range: mean percent of hits on 7 successive trials of 25 rounds each (N=149, Class 44-37, Laredo, Aug. '44)

sonnel that the Basic Deflection Range resembled the gunner's problem in position firing more closely.

Basic Deflection

Description of the Basic Deflection Range.—Essentially, the Basic Deflection Range included the modifications of skeet described above, with one additional innovation. An iron sight including three concentric rings was mounted on the shotgun barrels, and these were designated "1," "2," and "3" rads as required to apply position firing rules. These rings were so designed that by sighting along the appropriate ring and a post mounted on the end of the barrel, it was possible to score hits. Proponents of skeet believed that this range helped to give the gunner confidence in sighting systems, and it provided a simple introduction to the use of sights and firing.

Reliability of Basic Deflection Range scores.—A study of the reliability of basic deflection scores, conducted at Laredo in November 1944 and based on the performance of 95 students firing 25 rounds on each of 6 successive days, gave a reliability for the total score of 0.87. The Hoyt method was used. For the same data, the reliability of the last 3 trials, of 25 rounds each, turned out to be 0.82.

Learning on the Basic Deflection Range.—A learning curve for basic deflection firing was obtained on the basis of scores of 149 men, members of class 44–37 at Laredo, who fired on this range as part of their basic gunnery training. The results, presented in figure 9.16 and table 9.26 revealed that appreciable improvement occurred on the first 5 trials but that the remaining 2 trials yielded little improvement. This indicated that learning did occur under usual training conditions; and suggested that at least 5 trials were effective in producing gains in proficiency.

TABLE 9.26—*Learning curve data for basic deflection range: Mean scores and percent hits for 7 successive trials of 25 rounds each (N=149, class 44–37, Laredo, August 1944)*

Trial	Mean score	SE_M	Percent hits
1	10.8	0.31	43.2
2	11.6	.40	46.4
3	12.8	.35	51.2
4	13.4	.34	53.6
5	14.3	.32	57.2
6	14.1	.35	56.4
7	14.6	.36	58.4

The value of the Basic Deflection Range was assessed in a study carried out at Kingman.[21] In this study, the effect upon moving

[21] The study is described in the section on the Moving Base Range, p. 195.

base and gun camera scores of the elimination of basic deflection firing from basic gunnery training was determined. Since the design of the experiment involved the Moving Base Range as a central feature, the description of the procedure followed will be presented in the following section on the Moving Base Range. It may be noted here, however, that the results of the Kingman study gave no reason to believe that the elimination of basic deflection firing would have any appreciable effect on proficiency in moving base or gun camera firing.

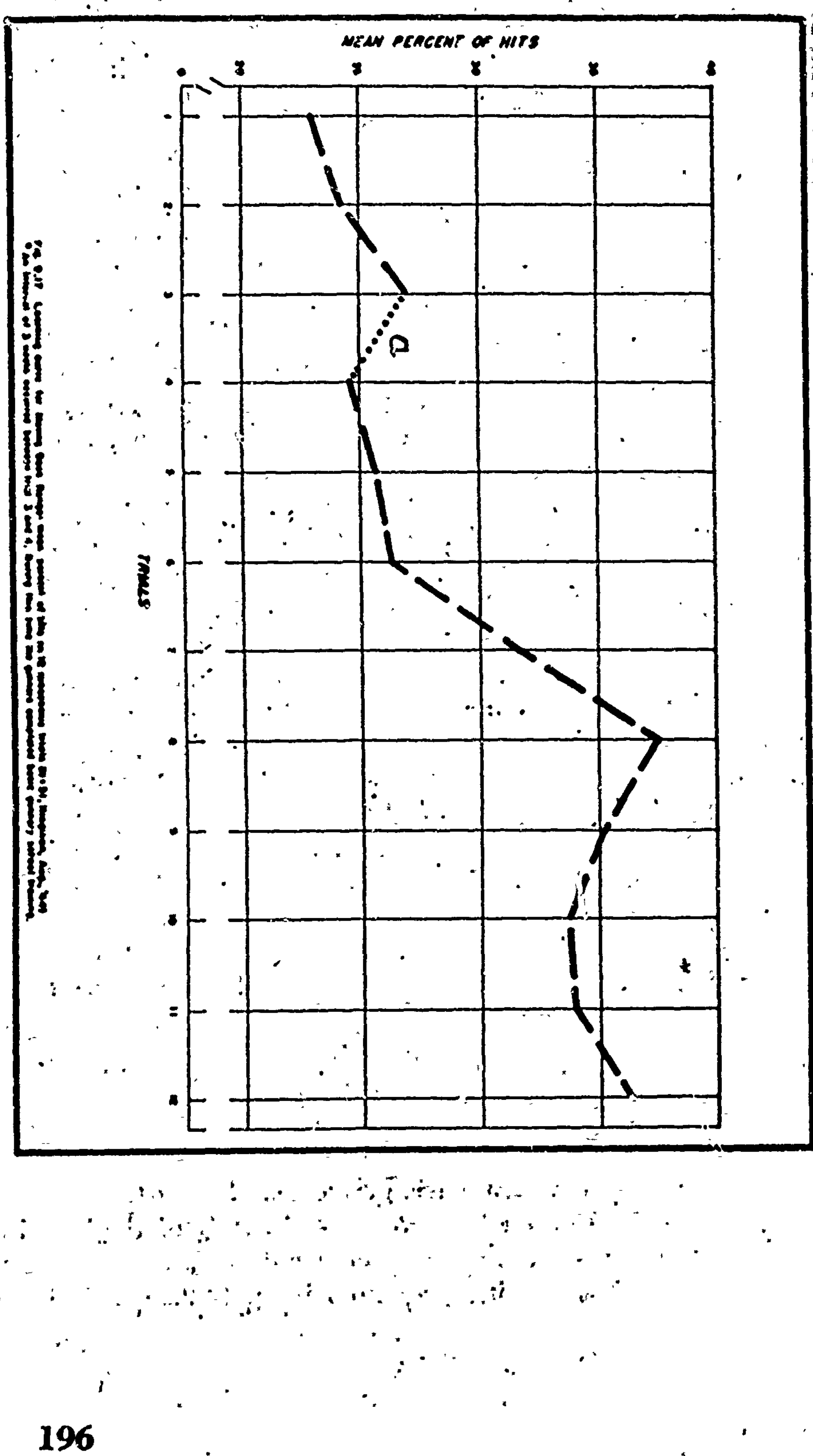
Moving Base Range

Description of the moving base range.—The distinctive feature of the variation of skeet known as the moving base range was the fact that it required the gunner to fire at a moving target from a moving base. In this range, the moving targets were skeet birds; the moving base, a truck maintaining a speed of 15 to 25 M.P.H., while traveling around a large elliptical track. Typically, the shotgun which the gunner fired on this range was mounted on a swivel and equipped to provide as much resemblance to a hand-held machine gun as possible. Since gunners were not likely to have had much previous experience in firing from a moving mount, the range provided an opportunity to experience the influence of this movement on the path of the shots fired. While the other shotgun ranges were being reduced in importance in gunnery training, moving base advanced from 8 hours and 150 rounds in August 1943 training standards to 16 hours and 300 rounds in the May 1944 training standards. However, the gunner was forced to rely largely on the instructor to know where to shoot, and, as a result, this trainer failed to give the gunner the opportunity to gain increased confidence in his ability to use correct sighting methods.

Reliability of Moving Base Range scores.—A study of the reliability of the Moving Base Range as it was functioning at Laredo in November 1944 showed a value of 0.91 for total scores on 10 trials of 25 rounds each, as computed by the Hoyt method (N=229). For the last 100 rounds, the reliability was estimated at 0.80 by the same method. A satisfactory consistency of scores apparently existed from trial to trial. (An earlier study of reliability in February 1944 yielded a value of 0.68 for this range, based on scores of about 250 basic gunners at Laredo).

Learning on the Moving Base Range.—A study of the learning curve on Moving Base Range was conducted at Kingman.[22] The interpretation of the results, presented in table 9.27 and shown

[22] This study was done by Lt. Ralph F. Wagner and Lt. Thomas P. Gallagher.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graphically in figure 9.17, is complicated by the fact that the 51 gunners included in the determination received 3 trials of 75

Table 9.27.—*Learning curve data for moving base range: Mean percent hits and standard error of means for 12 successive trials of 75 rounds each (N=51, Kingman, August 1944)*

Trial	Mean	SE_M
1	22.9	1.49
2	24.2	1.81
3	27.0	1.82
4[1]	24.6	1.68
5	25.6	1.45
6	26.2	1.46
7	31.6	1.21
8	37.4	1.50
9	35.2	1.46
10	33.7	1.42
11	34.0	1.47
12	35.3	1.85

[1] Approximately 3 weeks intervened between trial 3 and trial 4.

rounds each during their basic gunnery training, and then received an additional 9 trials of 75 rounds each after they had completed basic gunnery training. The data indicated rather clearly that improvement in score occurred with practice, and that 3 trials of 75 rounds each failed to exhaust the possibilities for relatively rapid improvement. The drop in score following the period of 3 weeks of other gunnery training may have resulted from lack of practice, from an interference effect of other types of gunnery training on moving base proficiency, from reduced effort by students or instructors on the early post-graduation trials, or from some other uncontrolled shift in firing conditions which occurred during this period. The rather erratic performance of the gunners during the last 5 trials implied a need for caution in interpreting the results. However, a rough estimate of the number of trials during which scores improved rapidly would place the figure at between 6 and 9 trials, which would involve firing from 450 to 675 rounds on this range. The maximum allotted to this range at any time in gunnery training was 300 rounds.

A validation study of the Moving Base Range.—The value of the Moving Base Range as a trainer was seriously questioned as a result of an evaluation of this range and of the Basic Deflection Range at Kingman which was done in the summer of 1944.[22] This study undertook to determine the effect of basic deflection and of moving base, both separately and together, upon gun camera scores. As an additional outcome, an estimate of the effect of basic deflection training upon moving base proficiency was obtained. In this study, a total of 153 basic gunners were divided at random into four groups as follows:

[22] This experiment was conducted by Lt. Ralph F. Wagner and Lt. Thomas P. Gallagher.

Group I (35 men) omitted training on the Basic Deflection Range.
Group II (37 men) omitted training on the Moving Base Range.
Group III (41 men) omitted training on both the Basic Deflection and Moving Base Ranges.
Group IV (40 men) received the usual 6 weeks of basic gunnery training.

The groups which omitted some portion of the training were given drill or squadron duty during the free time thus made available.

The first set of results of this experiment provided an evaluation of basic deflection. A comparison of the moving base scores of group I, which omitted basic deflection, with those of group IV, which had two 2-hour periods of basic deflection showed a slight and unreliable difference in favor of the group who had fired basic deflection, as shown in table 9.28.

The second set of results in this study was based on gun camera scores of gunners firing from the waist gun position. All gun camera scores used were obtained during 2 successive days of firing. Prior to these days, every student had flown at least one gun camera flight. Airplanes were loaded in such a manner that each of the 4 groups was represented equally in each bomber. Instructors were given a special orientation on the procedure to be followed during these days. Of the 6 attacks fired at on each day, the third and fourth were used for scoring where the film was clear enough to be scorable. For waist gun attacks, scores were obtained for about 77 percent of the gunners included in the ex-

TABLE 9.28.—*Effect upon moving base scores of eliminating training on basic deflection range (Kingman, August 1944)*

	N	Moving base scores		Diff	CR
		M	SD		
Group I: Training omitted Basic Deflection	35	24.55	5.90	2.40	[1] 1.73
Group IV: Training included Basic Deflection	40	27.00	6.42		

[1] A difference as large as 2.40 and in the expected direction would be expected to arise by chance approximately 4 times in 100.

TABLE 9.29.—*Effect of eliminating basic deflection and/or moving base on gun camera scores: Mean gun camera scores (waist gun firing) for gunners trained under each of four training regimes (Kingman, August 1944)*

	N	Mean error (in mils)	SE_M
Group I—(No basic deflection)	23	52.2	3.9
Group II—(No moving base)	28	49.1	3.6
Group III—(No basic deflection or moving base)	35	51.1	5.0
Group IV—(Usual gunnery training) [1]	29	50.4	4.3

[1] Usual gunnery training included 2 hours on the Basic Deflection Range and 16 hours on the Moving Base Range.

periment. These scores were based upon from 1 to 4 scorable attacks for each subject retained. The results obtained on waist gun firing, which required the gunner to take deflections in aiming, are reported in table 9.29. No differences of a size greater than those to be expected to arise by chance appeared among the 4 groups.

The absence of marked variations in the gun camera scores among the four groups suggested that the dropping of Basic Deflection training or of Moving Base training would have relatively slight influence on the gunner's proficiency in sighting, at least, as measured in the gun camera situation. Of course, this experiment does not provide proof that these ranges are without value for gunnery training; but it does suggest that whatever contribution to sighting and tracking ability they might make is adequately taken care of by the other ranges and trainers.

High Tower

Description of the High Tower Range.—The High Tower (or shotgun turret) range represented another variation of skeet. On this range, the student fired a shotgun mounted in a Crocker-Wheeler turret (a type of turret not used in combat aircraft) at regulation skeet birds ejected from a high tower. This range required the gunner to track and aim by manipulating a turret. It also gave experience in sighting, using an optical sight. The similarity to the gunner's job in aerial combat was reduced by differences between the turrets used on this range and the various turrets used in combat; by the need for an arbitrary sighting system used on this range only; by differences between the flight course of the birds and that of attacking fighters; and by the fact that shotguns rather than machine guns were fired.

Reliability of High Tower Range scores.—A study of the reliability of scores on this range carried out in November 1944, and based on the records of 82 students who fired 3 trials of 25 rounds each on each of 2 successive days, gave an estimated value of 0.67 for all 6 trials. The firing was done as part of their gunnery training. The Hoyt method was used for this determination. By the same method, a value of 0.72 was found for the last 3 trials.

Learning on High Tower Range.—A learning curve for this range was obtained by an analysis of records of 258 students, in Class 44–30 at Laredo, who fired 7 trials of 50 rounds each during their training. These results are shown in table 9.30 and figure 9.18. Although it is noticeable that a marked improvement in performance occurred on the second trial, further trials appear to show little upward trend. In terms of the training program in

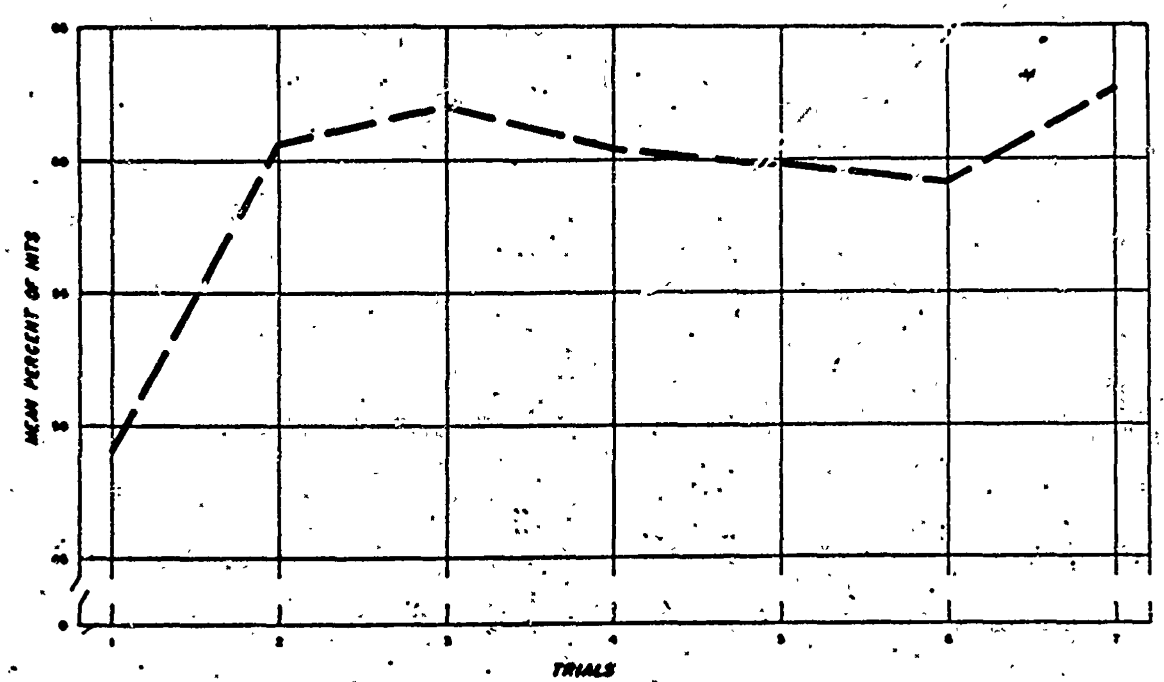

Fig. 9.10 Learning on the High Tower Range: mean percent of hits for successive trials of 30 rounds each (N=[illegible], Class 44-30, Laredo, July '44)

TABLE 9.30.—*Learning curve data for high tower range: Mean scores, standard errors, and percent hits for 7 consecutive trials of 50 rounds each (N=258, class 44–30, Laredo, July 1944)*

Trial	Mean	SE_M	Percent hits
1	24.5	0.44	49.0
2	30.3	.37	60.6
3	31.0	.44	62.0
4	30.2	.40	60.4
5	29.9	.39	59.8
6	29.6	.40	59.2
7	31.3	.32	62.6

operation at the time this study was done, results indicated that two trials of 50 rounds each would be sufficient to bring about most of the gain in proficiency attained.

Giant Skeet

Description of the Giant Skeet Range.—The Giant Skeet Range resembled the Basic Deflection Range in that the gunners fired shotguns mounted so as to resemble hand-held machine guns. The guns were equipped with iron sights with three concentric circles corresponding to 1, 2, and 3 rads. The deflection used for targets approaching at different angles corresponded (in name) to the appropriate deflection required by Position Firing for the same angles of approach. The Giant Skeet Range differed from ordinary skeet and basic deflection in that the traphouses were 100 feet apart and 20 feet high, so that the students were given greater opportunity to track before firing at the bird.

Reliability of Giant Skeet Range scores.—In the study of this trainer conducted at Buckingham in June of 1944, a reliability of 0.70 was estimated by applying the Spearman-Brown formula to an average intercorrelation of 0.165 for scores on 12 trials of 30 rounds each.[24] The scores of 20 subjects were used in these calculations. Kuder-Richardson formula No. 21 yielded an estimated reliability coefficient of 0.77 for total scores on 12 trials (360 rounds). The subjects in this study had not had previous gunnery training.

Learning of Giant Skeet.—A learning curve for the same 20 gunnery students on this range was determined as part of the same study. This curve was based on scores of all students who fired Giant Skeet, since examination of the data gave no evidence of any substantial difference in Giant Skeet proficiency between the experimental and alternating experimental groups. (The data were derived from the experiment described below). Each group fired 2 trials of 30 rounds each on each of 6 successive days.

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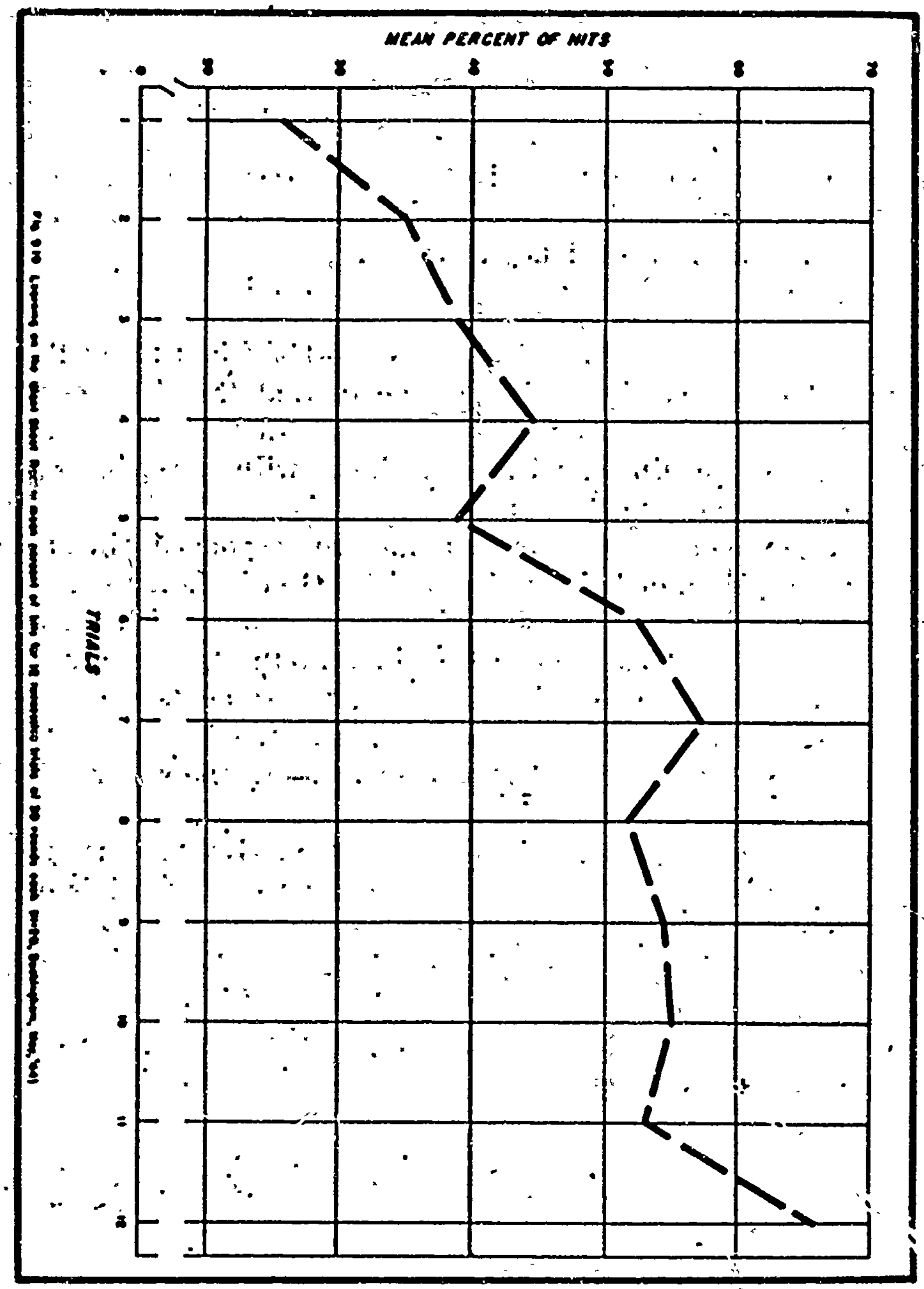
[24] This investigation was conducted by Maj. Roger W. Russell, assisted by Lt. William K. Estes, Lt. William B. Schrader, Lt. Esten W. Ray, and S. . Alexander N. Levine.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Evidence on the course of learning for Giant Skeet is presented in figure 9.19, and table 9.31. It is apparent that appreciable gains in proficiency occurred for these inexperienced gunners.

A validation study of the Giant Skeet Range.—As part of the same study an effort was made to obtain a preliminary estimate of the value of this range for teaching the Position Firing method of sighting. The criterion used was number of hits on the DeVry Panoramic Trainer, a device which required the gunner to manipulate a turret in order to score hits on pursuit curve attacks. (A more detailed description of this trainer is presented earlier in this chapter). In spite of certain dissimilarities between the two trainers, it was believed that improvement in knowledge of the Position Firing method of sighting should be reflected in increased proficiency on the panoramic trainer, which required the application of position firing rules.

TABLE 9.31.—*Learning curve data for giant skeet: Mean percent hits for 12 successive trials of 30 rounds each in Giant Skeet firing (N=20, Buckingham, May 1944)*

Trial	Mean percent hits	Trial	Mean percent hits
1	25.7	7	57.3
2	35.0	8	51.7
3	39.0	9	54.3
4	44.7	10	55.0
5	49.0	11	53.0
6	52.3	12	65.7

In this validation study, 40 untrained gunners were divided at random into 4 groups of 10 each. The first group (experimental) received an initial explanation of correct procedure for Giant Skeet firing, followed by 12 trials of 30 rounds each at the rate of 2 trials a day. The second group (alternating experimental) received the same training on giant skeet, and in addition received a trial on the Panoramic Trainer following each Giant Skeet trial. It was believed that the alternation between the two trainers might facilitate transfer. The third group (control) received no training. The fourth group (alternating control) received no Giant Skeet training, but had the same training on the Panoramic Trainer as did the alternating experimental group. All four groups were given a single trial on the Panoramic Trainer as a pretest and another trial as a post-test. The training of the alternating experimental and alternating control groups was not fully effective because of difficulties with the scoring mechanism on the Panoramic Trainer. These difficulties were, however, equivalent for both of these groups.

The results of this experiment are presented in table 9.32. It was found that the experimental group was somewhat superior in

proficiency on the Panoramic Trainer to the control group and that the alternating experimental group was somewhat superior to the alternating control group. However, the samples used were too small, in view of the size of the differences obtained, to permit the formulation of definite conclusions regarding the value of this range.

The Giant Skeet Range was never introduced into the basic gunnery program, so further studies of it were not carried out.

MACHINE GUN RANGES

Introduction

The evaluation of machine gun ranges was complicated by the fact that various modifications were introduced in these ranges from time to time to bring them into line with newer developments in gunnery methods and equipment and by the relatively large amounts of space and equipment utilized by these ranges, a condition which made standardization difficult. Variations in maintenance of equipment, in the scoring of targets, and in weather conditions were difficult or impossible to control properly on these sprawling outdoor installations, so that the interpretation of scores was difficult. However, machine gun ranges played a definite role in gunnery training throughout the war, and a number of studies were conducted in an effort to evaluate existing and newly developed machine gun ranges.[25]

TABLE 9.32.—*Validation of Giant Skeet using Panoramic trainer as a criterion (N=40 inexperienced gunnery students, Buckingham, May 1944)*

	N	Pretest		Post-test		Diff Exp. vs. Cont.	SE_{diff}	t
		M	SD	M	SD			
Alternating experimental	10	51.2	27.1	200.1	71.0	39.1	30.9	[1] 1.3
Alternating control	10	51.2	27.6	161.0	59.7			
Experimental	10	54.1	20.3	150.4	21.4	17.0	18.4	[2] 0.9
Control	10	50.0	26.8	133.4	50.3			

[1] This value would be expected to arise by chance between 20 and 30 times in 100.
[2] This value would be expected to arise by chance between 30 and 40 times in 100.

Moving Target Ranges (Hand-held and Turret)

Description.—The Moving Target (or jeep) Ranges derived their name from the fact that on these ranges the gunner was required to fire at a large cloth target (usually providing a scoring

[25] Studies of the reliability of the machine gun ranges, unless otherwise specified, were carried out by Sgt. Alexander Levine under the direction of Lt. Esten W. Ray. Studies of the learning curves, unless otherwise specified, were carried out by S/Sgt. Burton R. Wolls and Lt. William B. Schrader under the direction of Capt. Lee O. Garber.

area of 6 feet by 6 feet) which was drawn across the line of fire (usually by a jeep). In accordance with the type of equipment provided for firing, each range was designated Moving Target (hand-held) or Moving Target (turret). These ranges were designed so that the gunner fired on the target at each of 2 distances; namely, 200 yards and 400 yards. The target was drawn around an oval track during firing at a speed of approximately 25 M.P.H. In the earlier period of gunnery training, caliber .30 machine guns were used for most of the firing on Moving Target Ranges, but by the summer of 1944, these had given way to the caliber .50, the weapon fired in combat.

Reliability of scores.—Several estimates of the reliability of Moving Target Ranges were obtained in 1942. Scores of 254 students in Class 42–44, at Tyndall, yielded a reliability of 0.19 for caliber .30 firing on Moving Target (hand-held). This was based upon scores on the first 100 vs. the second 100 rounds fired, with the resulting correlation coefficient corrected by the Spearman-Brown formula. During the same year, a study of the reliability of caliber .30 firing on the Moving Target (hand-held) Range at Las Vegas showed a reliability coefficient, after correction by Spearman-Brown formula, of 0.58 for the first 250 rounds vs. last 250 rounds. The size of the population is not known. Scores on 253 students on the caliber .50 Moving Target (hand-held) at Tyndall yielded a corrected coefficient of 0.15 for first 50 vs. last 50 rounds. In the same study, a value of 0.03 was found for the reliability of scores on first 75 vs. second 75 rounds fired on the caliber .50 Moving Target (turret) Range, on the basis of 252 cases.

In November 1944, reliability estimates were obtained for caliber .50 firing on the Moving Target (hand-held) Range at Laredo. These estimates were based on the records of 130 students who fired 180 rounds at the 200-yard distance and the same number of rounds at the 400-yard distance on each of 3 successive trials. For the 200-yard distance the reliability of the sum of scores on all 3 trials was found to be 0.70, and the reliability for the sum of scores on trials 2 and 3, 0.67. For the 400-yard distance, the reliability of the sum of scores on all 3 trials turned out to be 0.56, with a value of 0.54 for trials 2 and 3. For total score on both distances, a reliability of 0.74 was obtained; the corresponding value for the last 2 trials being 0.71. All reliabilities in this study were obtained by the Hoyt method.

In connection with the reliability study conducted at Laredo, correlations between scores at the 200-yard range and the 400-yard range on the Moving Target (hand-held) Range were com-

puted for the scores of the same 130 students. For trial 1, this value was 0.08; for trial 2, 0.10; for trial 3, 0.30; and for the sum of 3 trials, it was 0.31. These results implied that the different distances imposed somewhat different but related tasks upon the gunner.

Usefulness of the Moving Target Range.—No learning curves or validity studies are available for these ranges. On logical grounds it appeared that the firing of the caliber 0.50 weapon was an experience which had possible training value. Both on the hand-held and turret forms of this range, the student received practice in using the same equipment he would use later in combat. However, the fact that these ranges required the use of an arbitrary sighting system represented a very severe limitation of their all around usefulness as a training device. On the whole, these ranges probably had their greatest value in enabling the gunner to become familiar with the firing and maintenance of the machine gun and to practice controlling it effectively either by proper handling of his hand-held gun or by proper manipulation of his combat-type turret.

Burst Control

Description.—Except for a small amount of firing on the Preventive Maintenance Range, a range used to teach prevention and correction of malfunctions, the gunnery student received his first experience with the caliber .50 machine gun when he fired on the Burst Control range. This range provided a stationary target, at a distance of 1,000 inches from the firing line, at which the gunner fired using a hand-held machine gun. The gunner's score was the number of hits falling within a circle 10 inches in diameter. Since experience had led gunnery experts to believe that 12 rounds constituted the optimal length of burst for many flexible gunnery conditions, the gunner was taught on this range to become familiar with the 12-round burst, and at the same time to hold the gun steadily on a stationary target while firing the burst.

Reliability of scores.—The reliability of scores on this range was estimated in November 1944, on the basis of scores earned by 226 basic gunnery students at Laredo, who fired one trial of five 12-round bursts on each of 6 successive days as a part of their regular gunnery training. Using the Hoyt method, a value of 0.84 was obtained for all six trials (360 rounds) and a value of 0.80 obtained for the last three trials (180 rounds).

Following the introduction of the improved K-7 gun mount, it was found that markedly higher scores were being obtained on this range. A study was initiated to estimate the reliability of scores under the new conditions, giving consideration also to the

relation between the size of the target circle and reliability of scores.[26] The firing was done by 50 students in Class 44–52 at Laredo, selected at random from the class, who completed fifteen 12-round bursts on the first day, and twenty 12-round bursts on the second day.

The relationship between target diameter and the estimated reliability for 35 bursts (420 rounds) was as follows:

2-inch diameter	0.65
4-inch diameter	.80
6-inch diameter	.84
8-inch diameter	.88
10-inch diameter	.89

All reliabilities were computed by the Hoyt formula. The values obtained for the three larger sizes were considered satisfactory.

Learning on the Burst Control Range.—Studies of the learning curve for the Burst Control Range were conducted both for the older mount and for the new K–7 mount. For the older mount, the data were based on the records of 130 students in Class 44–37 at Laredo, who fired a minimum of 15 bursts of 12 rounds each. The data on the improved mount were obtained on the basis of the records of the 50 students whose scores were used in the reliability study. Table 9.33 and figure 9.20 present data for the older mount using a 10-inch diameter target, and for the K–7 mount for 6-inch and 10-inch diameter targets. Improvement in scores occurred in each instance. Interpretation of the data for the K–7 mount is complicated by the fact that the first 15 and the last 20 trials were fired on different days. The results suggested that although improvement was most conspicuous during the early

TABLE 9.33.—*Mean hits per burst on successive groups of three 12-round bursts on burst control range.*

Trial	Old mount[1]	K–7 mount[2]	
	10 inch diameter target	6 inch diameter target	10 inch diameter target
1–3	2.18	2.53	5.08
4–6	2.86	3.23	6.18
7–9	3.27	3.30	6.52
10–12	3.59	3.41	6.77
13–15	3.61	4.41	7.30
16–18	—	3.98	7.31
19–21	—	3.87	7.09
22–24	—	3.87	7.33
25–27	—	4.48	8.08
28–30	—	4.28	7.91
31–33	—	4.76	8.44
34–35	—	4.51	8.48

[1] N=130, Class 44–37, Laredo, Aug. 1944.
[2] N= 50, Class 44–52, Laredo, Dec. 1944.

[26] This study was conducted by Capt. Lee O. Garber and Sgt. Alexander N. Levine.

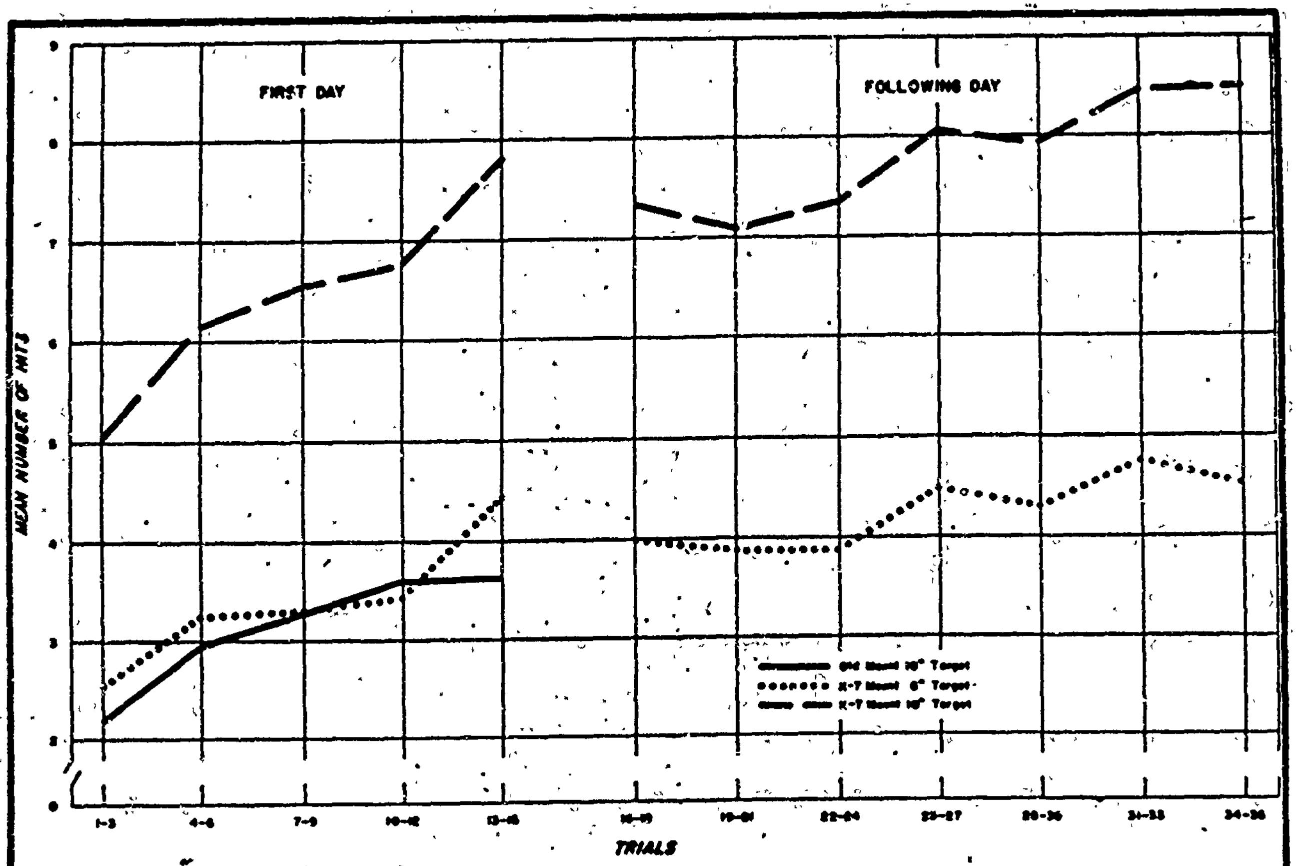

Fig. 8.20 – Learning at Laredo Central Range: mean number of hits scored in successive groups of three 10-round bursts by 130 gunnery students using old mounts and 10" diameter target (Aug. '44, Laredo); and 30 gunnery students using the K-7 mount as scored for the 6" diameter target and for the 10" diameter target (Dec. '44, Laredo)

trials, some additional gains continued to appear during 25 or more 12-round bursts.

No validation of this range was carried out. It was considered that the Burst Control Range helped to familiarize the gunner with the operating characteristics of his weapon and to enable him to practice controlling the pattern of his fire-burst. Its lack of value for sighting, tracking, and turret manipulation training were self-evident. Inclusion of a moderate amount of training on Burst Control early in the gunner's training appeared to be justified in the absence of definite evidence on its contribution to gunnery proficiency.

The Poorman Range

Description.—The Poorman Range required the gunner to take correct Position Firing deflections while firing caliber .50 machine guns at a stationary target. The underlying principle upon which this range was based was the resolution of the pursuit curve into two components: one transitory; the other, rotational. The translatory component was provided by having a small model airplane move in a straight line. A rotatory component was taken care of by introducing a rotation of the base on which the turret was mounted. This rotation had the same rate as, but was opposite in direction to, the rotation which the gunner would have to give the turret in tracking a pursuit ship flying a particular type of attack on his bomber. The sights were adjusted in relation to the guns so that the gunner sighted on the small model airplane referred to above, but the guns were bore-sighted on a stationary cloth target 1,000 inches away. The use of this fixed target was made possible by the fact that perfect performance on this range resulted in an exact compensation for the counter-rotation introduced in the turret base. This arrangement required, however, that the gunner be unable to sight directly on the fixed target.

This ingenious range had several limitations. It could not duplicate pursuit curves in which fighter aircraft attacked from above or below the bomber, since rotatory movements in the turret base were in azimuth only, never in elevation. In addition to this limitation, the range did not adequately give the gunner the illusion that he was seeing a pursuit curve, which made practice on this range seem somewhat artificial. Finally, it was necessary to tell the gunner the angle-off of the attacking plane at the beginning of the attack, although in combat the judgment of this angle represented an important part of the gunner's job in applying Position Firing rules.

A scoring procedure for Poorman Range targets was developed

empirically on the basis of a simple analysis. It was found that among 7 systems of varying degrees of complexity, the convenient method of counting hits falling within a 20-inch (diameter) circle yielded the highest reliability coefficient.[27] This method of scoring was also well suited to introduction for routine use. (Details of the statistical analysis are not available).

Reliability of scores.—An estimate of the reliability of Poorman Range scores was obtained for the Martin turret positions at Laredo as part of a learning experiment to be described below. In this experiment, 20 gunnery graduates who had not previously fired on the Poorman Range received the following practice. Trials involving the firing of 60 rounds each were fired on each of the 5 available attacks in sequence, which procedure was continued until each gunner had fired 3 times on each attack, for a total of 15 trials. A correlation of 0.30 was found between scores on trials 1–5 and those on trials 6–10, and a correlation of 0.22 was found between scores on trials 6–10 and those on trials 11–15. The correlation between scores on the first five and last five trials was 0.36. From these values, it was estimated, by applying the Spearman-Brown formula to the average intercorrelations, that the reliability of total scores on all 15 trials was 0.56.

Learning on the Poorman Range.—The first study of learning on the Poorman Range was based on scores obtained on the Laredo range in September 1944. At this time, each position was designed to simulate a particular type of attack. The position used represented attacks having 0°, 11¼°, 22½°, 45°, and 90° as their initial angle-off, and closing according to a pursuit curve path. Previous experience had indicated that the various positions varied markedly in difficulty.

The design of this study was based in part upon practical considerations in order that the method used in the experiment could also be followed in routine firing in gunnery schools. Specifically, trials were defined in terms of number of rounds (60 rounds of ammunition to a trial) instead of the number of attacks presented to the gunner. Moreover, the firing was done so that all equipment was used at all times during the firing. Since the standard equipment for the range at that time included 5 turrets, each presenting a different attack to the gunner, the gunners were divided into 5 groups, each group beginning its training on a different position. In order to provide a simple, orderly sequence of training on the 5 attacks, all gunners advanced, after each trial, to the next more difficult attack, except of course the gunners who fired

[27] This particular target design and the method for scoring it were conceived by Lt. Clarence F. Willey.

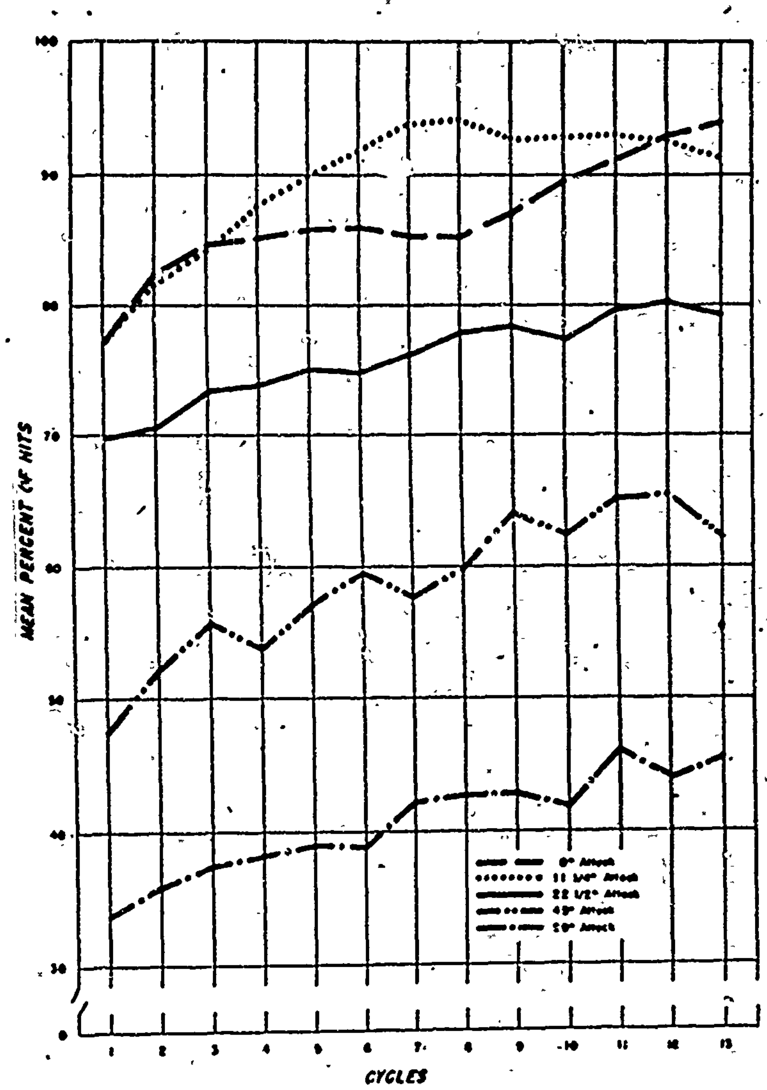

Fig. 9.21 Learning on the [illegible] Range (Martin Turret): mean percent of hits on each of 5 attacks during 13 successive cycles (N=20, Laredo, Sept. '44)

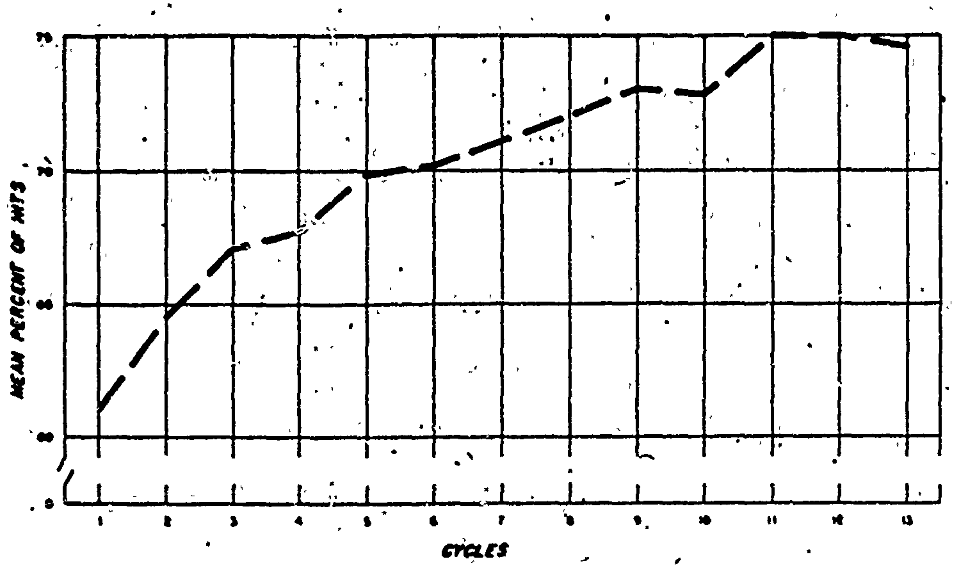

Fig. [illegible] - Learning on the Foreman Range (Martin turret): mean percent of hits on total of 8 attacks during 13 successive cycles ([illegible], Laredo, Sept '44)

on the most difficult attack. These gunners proceeded to the 0° attack which called for no-deflection firing and was therefore the least difficult attack. Changing to a new attack after each trial was considered desirable on the assumption that the gunner's learning problem was to master a technique for dealing with varied attacks, not to master each individual attack.

In determining the learning curves for data collected under this experimental design, it was found to be desirable to analyze the data in terms of a moving average, each point of which was calculated on the basis of the scores of all gunners on each set of five successive trials. Any series of five successive trials was called a cycle, since during such a series each gunner fired from each position. Scores were comparable from cycle to cycle inasmuch as all gunners received the same training on each cycle (only the order being varied). This method for analysis of the data was necessitated by the fact that scores from trial to trial were difficult to compare because the interaction between gunner ability and position difficulty became relatively large when the positions varied greatly in difficulty and the size of each subgroup of gunners was small.

Table 9.34 and figures 9.21 and 9.22 present data for performance on successive cycles of firing on each of the 5 attacks, and for the performance on all 5 attacks combined. It will be noted

TABLE 9.34.—*Learning on the Poorman Range (Martin turret): Mean percent hits on each cycle for each position and for total score (N=20 gunnery graduates, Laredo, September 1944)*

Cycle	Position					Total
	0°	11¼°	22½°	45°	90°	
1	77.1	77.1	69.8	47.4	33.7	61.0
2	82.2	81.6	70.6	52.1	35.9	64.5
3	84.6	84.2	73.4	55.7	37.5	67.1
4	85.1	87.5	73.8	53.8	38.3	67.7
5	85.7	89.8	75.0	57.1	39.1	69.8
6	86.0	91.8	74.9	59.5	38.9	70.2
7	85.4	93.9	76.2	57.7	42.1	71.1
8	85.4	94.2	77.8	59.8	42.7	72.0
9	87.0	92.7	78.4	64.0	42.8	73.0
10	89.5	92.8	77.4	62.4	41.9	72.8
11	91.2	93.1	79.6	65.1	46.1	75.0
12	92.9	92.7	80.1	65.5	44.0	75.0
13	94.0	91.4	79.1	[illegible]	45.6	74.6

that although only 20 gunners were used in the study, the average score for each cycle was based on 5 trials of 60 rounds each, fired by each of the 20 gunners. It must also be kept in mind that each cycle overlapped with each adjacent cycle, since 4 of the 5 trials included were identical between adjacent cycles.

The data indicated that learning progressed somewhat more rapidly on the earlier cycles and tended to level off during the

later cycles. Examination of the scores on individual positions showed that all except the 0° position showed fairly typical trends. The irregular trend of the 0° performance may possibly have reflected habit interference, since the shift from the 90° to the 0° position marked a sharp change in the responses required. Unfortunately, it happened that considerable difficulties were encountered in maintaining the harmonization on the turret which provided the 0° attack, so that the more probable interpretation of the irregularity considered it an artifact produced by equipment difficulties.

A further study of learning on the Poorman Range was made after this range had been modified so that various attacks could be presented on the same position. In this study, hand-held guns, on which a K–13 sight was mounted, were used. Since the K–13 sight was of the compensating type, it was necessary for the gunner only to maintain the center of the sight reticle on the target plane; a problem considerably less difficult than that presented by the fixed optic sights used in the earlier experiment.

In this study, 24 gunnery graduates who had not previously fired on the Poorman Range, and 24 gunnery students who had not yet begun gunnery training, were used.[28] The three attacks used were designed to represent 60°, 70°, and 90° pursuit curve attacks. Careful control was exercised over the duration of each attack, over the distribution of fire during each phase of the attack, and over the harmonization of the guns. A new scoring system was devised, since the introduction of the compensating sight made inadvisable the use of the simpler scoring system described above. Instead, a system involving a set of concentric circles, beginning with one having a radius of 2 inches, scored 10; the next with a radius of 4 inches, scored 9; the third, with a radius of 6 inches, scored 8; and so on until a circle of 20-inch radius with a score value of 1 was reached. Scores for each trial were determined by dividing the total score by the highest score attainable in the number of rounds fired, and multiplying the result by 100.

In this study, both groups of 24 gunners were divided into six sub-groups, each of which fired on the three attacks in a counterbalanced order. Each trial consisted of two presentations of the same attack, a maximum of 20 rounds being available for each of the two presentations.

The recording of scores included a notation as to whether the first bullet struck the target on the right or left side of the center line. Analysis of these results indicated that both trained and

[28] Lt. Victor A. Reinders conducted and reported this study. He was assisted by Sgt. Evlyn W. Harkrader and Cpl. George Massarsky.

untrained gunners showed a tendency to track too slowly with compensating sights. The ratio of strikes on the side of the target representing too slow tracking to strikes on the other side was 1.5 to 1 for the untrained gunners, and 1.3 to 1 for the trained gunners.

Table 9.35 and figure 9.23 present the average scores of the two groups on 18 trials. It was apparent that learning occurred most rapidly in each group on the first 10 trials but that some slight improvement was found in later trials. It was found that the untrained gunnery students overtook their more experienced fellows by the time the third trial was reached, after which the curves ran along together during the remainder of training.

TABLE 9.35.—*Learning on the Poorman Range (K-13 sight): Mean percent of perfect scores for 24 previously untrained gunners and for 24 gunnery graduates (Laredo, April-May, 1945)*

Trial	Trained gunners	Previously untrained gunners
1	50.3	25.3
2	59.2	53.5
3	55.3	55.8
4	61.6	62.0
5	65.1	66.1
6	55.4	66.5
7	64.4	60.0
8	69.2	64.7
9	71.2	68.0
10	70.9	71.8
11	73.4	69.2
12	72.1	72.2
13	67.5	69.8
14	73.3	72.1
15	70.9	74.6
16	73.2	72.8
17	71.3	73.6
18	[1] 73.0	[2] 74.4

[1] On 2 additional trials, it was found that if the target plane were held stationary, the mean score was 73.0; and that if the target plane were held stationary and no base rotation introduced, the score was 85.9.

[2] On 2 additional trials, with stated rewards for increases in proficiency, scores were 69.0 and 71.9.

For the untrained gunners included in this study, the 19th and 20th trials were used to determine whether increased proficiency might be shown if additional motivation were provided. The specific motivation involved the promise of special privileges to gunners who attained certain scores. Instead of increased scores, however, a slight drop in averages appeared.

For the trained gunners, trials 19 and 20 were used to determine the effect on scores of certain modifications of the gunner's task. On the 20th trial, no base rotation was used and a fixed aiming point was provided in an effort to determine the limiting score attainable under these much simplified conditions. The value was found to be 85.9.

Usefulness of the Poorman Range.—The Poorman Range was

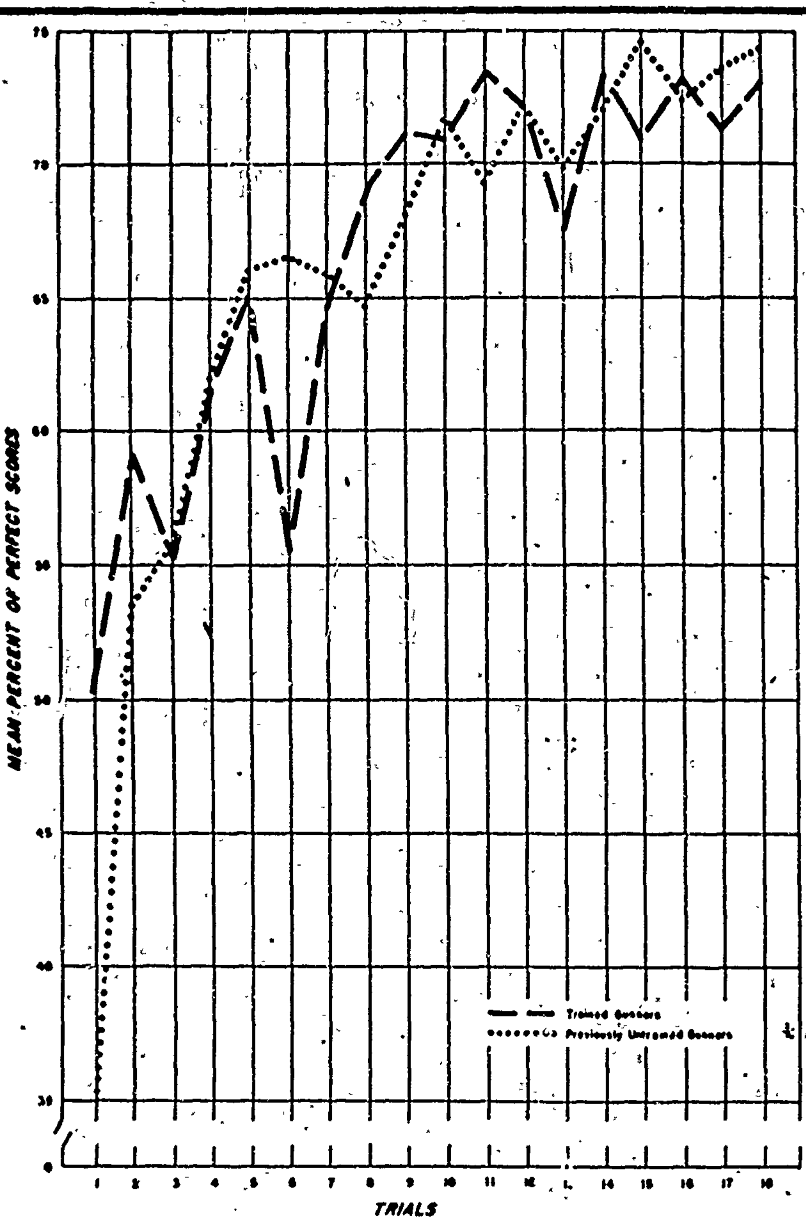

Fig. 9.23 - Learning on the Poorman Range (K-13 Sight) mean percent of perfect scores for 24 previously untrained gunners and for 24 gunnery graduates (Laredo, April-May '43)

considered to be useful for giving experience in the use of combat equipment under conditions favorable for instruction. The greater realism which it provided, together with the fact that it required the use of Position Firing rules, made it especially valuable as a trainer on the use of sights other than computing or compensating. In the absence of specific validating studies, the actual contribution of the Poorman Range to sighting proficiency could not be evaluated. However, the limited opportunity for variations in the attacks presented on this range emphasized that its main contribution lay more in the fact that the gunner got realistic practice in using his hand-held gun or turret than in bringing about improvement in ability to use his sights effectively for many varied attacks.

OQ–3 Radio Controlled Target Planes

Description.—The OQ–3 radio controlled target planes provided an opportunity for gunners to gain experience in tracking, ranging, and firing at a flying target. The target actually used was a large model airplane having a wingspan of 12 feet and a fuselage length of 8½ to 9 feet, powered by a twin-cylinder 8 h.p. engine. This model plane had rudder and elevator controls which could be controlled through the medium of impulses transmitted by radio from a ground unit. Take-off was accomplished by use of a catapult; and landing by use of a parachute which the "pilot" on the ground could open as necessary. The repair of planes shot down was, in general, relatively easy.[29]

The fact that a gunner, using combat type equipment, shot caliber .50 ammunition at a flying target which could occasionally be shot down (sometimes in flames) provided a realistic and stimulating experience for gunners. With B–29 sighting equipment, which involved computing sights, adjustments were made which enabled the gunner to use normal firing procedures at any range between 250 and 450 yards with satisfactory results. It was found in a tryout of the equipment that a trained B–29 crew was able to bring down two of the planes, using 246 rounds of ammunition on the first, and 220 rounds on the second. A count of the number of hits revealed that approximately 4 percent hits had been scored. Other firing showed much lower scores in percent hits. No specific evidence of the reliability of this range is available.

The OQ–3 Range appeared to be useful as a motivating device and for giving experience in firing live ammunition under rather realistic conditions. Because of the large number of radio main-

[29] Lt Cameron C. Stineman was responsible for the setting up and operation of the experimental OQ–3 Range at Laredo.

tenance and airplane repair personnel that would have been required to permit its extensive use for training, it was never adopted as a part of gunnery training. Learning or validity studies on this range were not carried out. The ease with which hits were obtained depended for the most part on the type of attacks flown; it was possible to maneuver the fighter so that thousands of rounds could be fired without obtaining hits. Unfortunately there was no way to standardize the types of attacks flown.

AIR TRAINING PROCEDURES

The aerial phase of flexible gunnery training was considered the culmination of the basic course. Important and elaborate as it was, the air training phase was beset with more and greater problems of attaining maximum realism, learning, adequacy of scores, and adaptation to changing techniques than any other phase of the gunnery course.

Air Firing

Description.—For the duration of the flexible gunnery training program it was common practice to give flying experience during the last 2 weeks of training. In the early days of the program this experience consisted of taking the gunners up in two-seated AT–6 planes and allowing them to fire caliber .30 machine guns from the open rear cockpits at the Gulf of Mexico or the deserts of the West. The next step included firing at flag targets which were towed in courses parallel to those of the gunners' planes; the air-to-ground and air-to-water firing was kept in the curriculum as a familiarizing experience. In 1943, a large number of twin-engined AT–18 airplanes became available, and in these were installed turrets modified to mount caliber .30 machine guns. It was customary to paint bullets several different colors so that several gunners could fire from one plane at the same target and have their hits later identified by the color of paint that had come off on the target. As combat types of aircraft became available, the gunnery trainee's job in the aerial situation came to simulate fairly closely the situation of combat in so far as his equipment and immediate surroundings were concerned. That the type of sighting problem the gunner had to solve in training bore little or no resemblance to the combat sighting problem remained the principal drawback of this type of training. Nevertheless, for lack of a more suitable air firing situation, the practice of firing at flag targets was continued.

Reliability and learning.—Since the air firing situation appeared to some to simulate "real gunnery," it was standard policy at one

time to use air firing scores as a basis for eliminating students from gunnery training. Because of the importance of a reliable elimination criterion, several reliability coefficients were computed by the Psychological Research Detachment at Buckingham. Total scores for odd numbered and even numbered missions were correlated for 14 basic gunnery classes representing 5 schools; these coefficients ranged from 0.05 to 0.80, with more than half being below 0.50 (gunnery classes at that time, 3d quarter of 1943, contained about 400 students). On the basis of these findings it was recommended that air firing scores no longer be considered in eliminating students from gunnery training; the recommendation was adopted.

A careful examination of the conditions obtaining in air firing revealed an almost complete lack of standardization. Several different sizes of target were used, range of firing varied from 100 to 400 yards, and pilots engaged in mild acrobatics to relieve the boredom of the routine, thus effectively terrorizing and otherwise incapacitating many a green student. Record keeping was very haphazardly administered—in one case a student was marked "Failed to fire" and yet received a score for the day, and in another a student fired two rounds on one mission, made one hit, and so received a score of 50 percent for the day.

Evidence of learning in the air firing situation was lacking; some performance curves plotted for several classes revealed random variations throughout the series of 6 missions. These curves are not reproduced here because some of the basic data are no longer available.

Variations of air firing.—Modifications of air firing procedures were conceived from time to time, particularly after the inception of Position Firing. One of these involved dropping brightly colored dyes into the water over which firing was being conducted, in such a manner that gunners in a plane flying by them in a straight course at an altitude of about 100 feet would have to apply proper Position Firing deflections in order to hit the colored area. A similar lay-out for air-to-ground firing was designed and adopted at the schools situated in the arid regions. Although no evaluations of these simulated pursuit curve ranges were conducted, it seemed likely that of the several methods of conducting air firing these ranges offered the best opportunity for the student to learn to apply Position Firing deflections, for the reason that the gunner received immediate knowledge of the results of his practice.

Conclusion.—In summary, it appeared that students derived little if any sighting proficiency from practice in the air firing situations. Probably the greatest value derived was a familarity

with the operation and manipulation of gunnery equipment while airborne. Both as a sighting trainer and as a criterion of proficiency, the air firing situations as conducted at this time appeared to be practically worthless.

The Gun Camera in Flexible Gunnery Training

The gunnery program floundered along with little hope of finding a criterion of performance outside actual combat until toward the end of 1943 when it became apparent that the use of the gun camera might lead the way to the answer. The gun camera was a small electrically driven camera using film 16mm. in width and 50 feet in length. It was mounted on or near the gun sight and took pictures ordinarily through the sighting head by means of a periscopic arrangement which allowed the camera to see the same thing that the gunner saw, while using the sight. The camera thus provided a record of just where the sight was pointed and how it behaved in relation to the target. This procedure was immediately hailed by many as the answer to their wishes, but the numerous complications arising when it was put into use soon proved that their relief was premature. After more than two and a half years of development and experiment, a large amount of information has been gathered about gun camera use and some tenable conclusions attained.

Description.—The role of the gunnery student in using the gun camera in air training was much the same as that of the gunner in combat with the exception that he was not bothered by the vibration of recoiling guns, or seriously concerned over his chances of returning alive to his base. His problems remained to track the attacking plane and allow proper deflections (if using a noncompensating or noncomputing sight), to manipulate his sight controls to "frame" the turret (if using a computing sight), or just to keep his sight reticle on the target (if using a compensating sight). The instructor had additional duties consisting primarily of carefully watching the simulated attacks being flown to determine if they resembled real attacks, then closing a switch, which started the camera, and opening the switch again at the end of the attack. As the gunner pressed his triggers a little pointer withdrew from the camera's field of view, thus allowing the scorers to know when the gunner was "firing." The pursuit pilot was briefed to make his "attacks" toward the shaded side of the bomber, so that the lens of the camera would not be pointed into the sun, and to make them as consistent as possible according to some plan previously arranged with the gunnery instructor and the pilot of the bomber. The bomber pilot had to take care to fly his plane as smoothly as possible and along courses which both

he and the gunnery instructor knew about in advance. All of this was done in order to standardize the procedure as much as possible.

Scoring.—The scoring of gun camera film, while mathematically simple enough, was a tedious chore and, because humans are subject to boredom and resultant inefficiency, was itself subject to much error. Film was normally scored through the use of the Ampro Scoring Viewer, a unit embodying both a 16mm. projector and a translucent projection screen through which the pictures were viewed. It was possible to determine readily linear distances on the screen in terms of mils, and thereby measure with a properly scaled rule the various kinds of sighting errors made by the students. To minimize the scoring routine, only every 10th frame of each attack was scored. It was determined that scoring every 10th frame gave as reliable a score as scoring every frame or every alternate frame. The various scores derived from gun camera film were generally expressed in terms of mil errors and may be described as follows:

1. Film exposed through computing sights:

a. Tracking errors: the distance in mils between the nose of the fighter and the center of the sight reticle.

b. Ranging errors: the difference in mils between the wingspan of the plane's image and the width of the opening in the movable sight reticle. This movable reticle appeared as two vertical lines in the Sperry K-3 and K-4 sights and as a variable sized circle of dots in the Sperry K-15 and the General Electric sights for the B-29.

2. Film exposed through compensating sights:

a. Because of the mechanism of a compensating sight, the guns would be pointed at the proper point of aim if the center of the reticle appeared to be on the nose of the attacking plane. Therefore tracking error, in terms of mils distance between the nose of the fighter and the center of the sight reticle, was used as the score.

3. Film exposed through noncomputing and noncompensating fixed sights:

a. At waist gun positions, not mounting computing or compensating sights, the gun camera installation included an assessing unit which automatically showed on the film the correct point of aim and the proper line of deflection. Scoring amounted to determining the mil distance between this point and the nose of the plane. A similar device, developed by the Navy, was used with turrets not equipped with computing or compensating sights. A full description of these assessing devices is contained in AAF

Manual No. 25, "Gun Camera Manual for Flexible Gunnery Training."

b. For purposes of research, film exposed through noncomputing, noncompensating ("fixed") sights on turrets was scored through the use of a deflectometer. The camera photographed the attacking plane and also two graduated scales which showed, in mils, the azimuth and elevation of the guns with respect to the bomber's position. By means of a device based on the principle of the compensating sight, the path of the bullets was projected on a viewing screen along with the picture of the attacking plane; the scoring consisted of measuring the distance between the nose of the attacking plane and the point at which the bullets would have intersected its line of flight. This score, in mils, was called "circular error."

c. Much time was saved, however, in scoring film taken through fixed sights on turrets if an arbitrary all-or-none "hit" score was used. Defining a hit as a circular error of not more than 15 mils, a circle 30 mils in diameter could be centered on the path of the projectiles and a hit scored if the center of the attacking plane was within that circle. The rank order correlation between this score and the circular error was found to vary between 0.89 and 0.96.

Factors affecting reliability of gun camera scores.—Because much importance was attached to the reliability of gun camera scores, a number of efforts were made to identify sources of unreliability in these scores, both by surveying operating conditions and by conducting experimental studies. As discussed below, the main requirements for obtaining reliable scores centered in controlling flight conditions and scoring procedures and in obtaining a film record of adequate length.

Conditions of flight affecting reliability.—Factors under condition of flight were:

1. Variability in attacks. In so far as the differences between attacks represented different levels of difficulty for the gunner, attack differences contributed to the unreliability of scores.

2. Variability in the course of the bomber. Though it was less difficult to control the course of the bomber than the course of the attacking fighter, some unreliability in scores was accounted for by differences in the smoothness with which the firing ship was handled from one attack or mission to the next.

3. Weather. The weather was a determinant of the smoothness of flight of both the fighter and the bomber, and variations in weather from mission to mission were frequently large and therefore contributed to the unreliability of a score derived over a period of several days.

4. Harmonization. There was also the possibility that the harmonization of the camera with the sight may have shown slight differences from mission to mission.

Conditions of scoring affecting reliability.—The second factor influencing reliability of gun camera scores was an administrative one. Scoring of film could be done accurately and had to be done accurately if satisfactory reliability was to be obtained. In three of the studies summarized in this section especial care was taken to ensure that the scoring process was reliable. Daily samples of film were rescored and if divergences between the scorers' and checker's results appeared, the whole batch of film would be rescored. Needless to say, the threat of having to rescore a large amount of film provided strong motivation to the scorers to exercise utmost care.

At one time it was suggested that a grading scale be adopted for general use in the gunnery schools which would allow a standard comparison of a gunner with his classmates. This scale was to make use of the combination of two scores: a subjective, qualitative rating, called an assessment, and the objective score as derived by the gun camera department. To investigate the merits of such a proposal, film from approximately 200 gun camera missions from Laredo classes 45–4 and 45–5 was examined, and the 20 clearest films taken through computing sights (Sperry ball turret) and the 20 clearest films taken through noncomputing sights (Martin turret) were selected.[30] The score for the computing sight film was the sum of the tracking errors in mils, and that for the fixed sight film was the sum of the directional (whether too high or too low) and the deflectional (amount of deflection) errors, also in mils. The assessments were based on general effectiveness, tracking error, tracking smoothness, framing error, and framing smoothness for the computing sight film; and for the noncomputing (fixed) sight film, general effectiveness, deflection, line of apparent motion, and smoothness. After assessment the performance was given a rating of one to five.

The scores originally derived by the film scoring department for final grades were used, and at a later date the film scoring department rescored this same film. Four experienced enlisted men assessed all of the film twice on successive days. Correlation coefficients were computed between the two sets of scores and between the two sets of assessment ratings. These are shown in tables 9.36 and 9.37 and clearly demonstrate that there was very little similarity between either the sets of the scores or the sets of assessments and also that two combinations of assessment ratings with scores had very little in common.

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30 The project officer for this investigation was Lt. Esten W. Ray.

TABLE 9.36.—*Reliability of Gun Camera Assessment: Correlation between first and second assessments: Each computation based on 2 attacks for each of 20 gunnery students (Class 45-4 and 45-5, Laredo, February 1945)*

	Computing sight rater number				Noncomputing sight rater number			
	1	2	3	4	1	2	3	4
Item I—general effectiveness	0.45	0.32	0.68	0.29	0.38	0.45	0.39	0.29
Total assessment sum of 5 items.	.46	.49	.80	.52	.29	.44	.01	.83

TABLE 9.37.—*Reliability of gun camera scores: Correlations between first and second scoring of film and between first and second composite scores based on combination of scores and assessment grade ratings; each computation based on 2 attacks for each of 20 gunnery students (class 45-4 and 45-5, Laredo, February 1945)*

	N	1st score vs. 2d score	1st composite vs. 2d composite
Computing	20	0.43	0.41
Noncomputing	20	.58	.07

Reliability under experimental conditions.—Since it was impossible to control completely the first two sources of unreliability, the most important actual determinant of reliability appeared to be the length of the sample obtained. In two studies [31] conducted jointly by the School of Aviation Medicine and the Central School for Flexible Gunnery the problems and the possibility of obtaining satisfactorily reliable gun camera records were demonstrated.

Experiment I.—One experiment, whose purpose was to measure the amount of transfer from practice on the E-8 Spotlight Trainer and the DeVry Panoramic Trainer to the camera criterion, yielded much information on the reliability of gun camera scores. Thirty-two gunnery graduates were divided into two groups of 16 each; one group was given three gun camera missions in the Sperry upper turret, followed by intensive training on the E-8 Spotlight Trainer and then three additional gun camera missions as before. Each mission for each man consisted of 6 attacks by a P-40 airplane under standard conditions. The other group was given three gun camera missions in the Martin turret, followed by intensive practice on the DeVry Panoramic Trainer and then three more gun camera missions as before. During the missions, the members of the two groups were flown so that influences of variations in bomber and fighter pilot, weather, illumination, and

31 These projects were conducted in collaboration with the School of Aviation Medicine, Randolph Field, Tex. Capt. Mason Haire, and S/Sgt. Riner C. Payne represented the Research Division of CSFG, and Capt. Moncrieff H. Smith represented the School of Aviation Medicine.

supervision were equalized for all subjects. Films were developed overnight and given a preliminary scoring in the morning, so that gunners could see the results of the preceding day's mission before the next flight in the afternoon.

In table 9.38 are shown inter-mission rank-order reliability coefficients for the tracking and framing errors of Sperry gunners and the circular errors of Martin gunners. The small size of these coefficients indicated relatively little relationship between the missions.

When the intramission reliability of gun camera scores was considered a similar picture was seen. Table 9.39 shows intramission rank-order coefficients obtained for the mean scores on odd-numbered attacks and even-numbered attacks on each mission separately, and for the first three missions and the last three missions. These coefficients were not corrected by the Spearman-Brown formula.

Experiment II.—In another study done at Laredo in collaboration with the School of Aviation Medicine, more evidence of the nature of gun camera score reliability was found. This study was primarily concerned with determining the amount of learning that would be realized by 32 graduate gunners on 10 successive gun camera missions.

TABLE 9.38.—*Reliability of gun camera scores: Rank order correlations of scores on single missions in terms of tracking and framing errors of 16 graduate Sperry gunners and of circular errors of 16 graduate Martin gunners (Laredo, 3d quarter, 1945)*

	Sperry gunners											
	Tracking errors						Framing errors					
	1	2	3	4	5	6	1	2	3	4	5	6
1	------	−0.16	−0.20	0.36	−0.65	0.67	------	0.32	−0.42	0.06	0.08	−0.03
2	−.16	------	.50	.08	.50	.22	−0.32	------	−.03	.42	.34	.08
3	−.20	.50	------	.46	.56	.45	−.42	−.03	------	.17	−.19	.25
4	.36	.08	.46	------	.31	.23	.06	.42	.17	------	.26	.27
5	−.65	.50	.56	.31	------	.80	.08	.34	−.19	.26	------	.30
6	.67	.22	.45	.23	.80	------	−.03	.08	.25	.27	.30	------

	Martin gunners circular errors					
	1	2	3	4	5	6
1	------	0.58	0.02	0.56	0.42	0.29
2	0.58	------	.07	.47	.42	−.67
3	.02	.07	------	−.01	.29	.02
4	.56	.47	−.01	------	.36	([1])
5	.42	.42	.29	.36	------	.41
6	.29	−.67	.02	([1])	.41	------

[1] Insufficient cases.

TABLE 9.39.—*Reliability of gun camera scores: Average of rank order correlation coefficients of scores on single missions in terms of Sperry mil tracking and framing errors and of Martin mil circular errors made by 16 graduate Sperry gunners and 16 graduate Martin gunners (Laredo, 3d quarter 1944)*

	N	Average intercorrelations		
		Missions 1, 2, 3	Missions 4, 5, 6	All missions
Sperry tracking error	16	0.05	0.50	0.20
Sperry framing error	16	—.05	.19	.11
Martin circular error	16	.11	.21	.15

Sixteen graduates who had specialized in the Martin turret and 16 who had specialized in the Sperry lower ball turret were given 10 successive gun camera missions over a period of 17 days. Since the operating mechanisms of the lower ball turret and the upper local turret were considered to be similar, the Sperry gunners were given their gun camera missions on the upper local turret. A mission consisted of six attacks for each man, three beginning from the 9 o'clock position and three from 3 o'clock; all were pursuit curve attacks. Bombers, fighter pilots, and instructors were alternated among the subjects so that the influence of each variable would be equal for all subjects. At the beginning of each attack the instructor started both cameras, or if the attack appeared to be wrongly made, he would inform the gunners and also the fighter pilot. In this way it was possible to ensure that both gunners operating at any one time fired at the same attacks.

Again rank-order coefficients for odd and even numbered attacks within each mission were computed and averaged. These are reported in table 9.40, as raw coefficients, not corrected by the Spearman-Brown formula.

Although the average intra-mission reliabilities came close to being acceptable, there was sufficient variation from one mission to the next to prohibit accepting any one mission as a reliable

TABLE 9.40.—*Reliability of gun camera scores: rank order correlations of scores made on odd and even numbered attacks within a single mission, in terms of Sperry mil tracking and framing errors and of Martin mil circular errors made by 16 graduate Sperry gunners and 16 graduate Martin gunners. (Laredo, fourth quarter, 1944)*

Measurement	1	2	3	4	5	6	7	8	9	10	Average
Sperry:											
Tracking	0.76	0.52	0.53	0.44	0.66	0.47	0.94	0.64	0.66	0.46	0.65
Framing	.70	.32	—.03	.84	.31	.09	.53	.54	.37	.60	.47
Martin:											
Circular error	.55	.54	.52	.64	(1)	.58	.29	.66	.79	.74	.60

[1] Mission 5 is omitted because of insufficient data.

index of the gunner's proficiency. Table 9.41 summarizes the degree to which scores from any one mission would predict scores on any other mission; the average intercorrelations presented here show again that one mission was not sufficiently representative of a man's performance to be used as a criterion of his ability.

TABLE 9.41.—*Reliability of gun camera scores: Average of rank order intercorrelations of scores on single missions, in terms of Sperry tracking and framing errors and of Martin circular errors made by 16 graduate Sperry gunners and 16 graduate Martin gunners. (Laredo, fourth quarter, 1944)*

	Sperry tracking	Sperry framing	Martin circular error
Average rho	0.05	0.42	0.26

Since a single gun camera mission was not sufficiently stable to be used as a measure of proficiency, it was necessary to determine how many such missions were necessary to produce satisfactory reliabilities. One approach was to consider the correlations among various combinations of scores. For instance, the scores on odd numbered attacks, and even numbered attacks throughout any two missions could be correlated; the same could be done with odd and even numbered attacks for any number of missions taken together. Also, the total scores for groups of missions could be combined and correlated with total scores of other groups of missions. Both of these processes were carried out. The latter method was considered to provide a more adequate estimate of reliability. The results are given in table 9.42.

TABLE 9.42.—*Reliability of gun camera scores: Rank order intercorrelations between scores made on odd and even numbered attacks within groups of missions, and between scores made on groups of missions by 16 graduate Martin gunners and 16 graduate Sperry gunners (Laredo, fourth quarter, 1944)*

	Odd vs. even attacks within groups of missions		
	Sperry tracking	Sperry framing	Martin circular error
Average rho within pairs of missions	0.61	0.63	0.64
1st 5 missions	.77	.67	.75
2d 5 missions	.72	.89	.85
1st 3 missions	.50	.51	.37
1st 6 missions	.75	.75	.86
10 missions	.81	.86	.91
RANK ORDER CORRELATIONS BETWEEN GROUPS OF MISSIONS			
Average rho between pairs of missions	[illegible]	0.59	0.51
Odd vs. even missions	[illegible]	.78	.74
1st 5 vs. 2d 5 missions	.68	.75	.56
Missions 1–3 vs. 1–10	.45	.63	.78
Missions 1-6 vs. 1–10	.92	.96	.94

No Spearman-Brown correction was applied to any of these coefficients.

It can be seen that pairs of missions provided a somewhat more stable score than single missions, but that the scores still were not satisfactorily reliable. For these data it appeared that five was about the minimum number of missions that could be given and still provide a sample of performance adequate to serve as a criterion of a gunner's proficiency. It must be emphasized, though, that unless the conduct of such missions had the closest supervision it was possible to have variation from mission to mission which might completely destroy the reliability of the scores.

It was also possible to compute reliabilities for these data by grouping the scores by days rather than by missions. There were 6 days on which all gunners flew. The correlations between scores grouped according to the *day* on which they were made were somewhat higher than when scores were grouped by mission number, which supports the contention that the influences of variations in type attack, turbulence of the air, state of equipment,

TABLE 9.43.—*Reliability of gun camera scores: Rank-order correlations between scores made on odd and even numbered attacks with data grouped by days rather than by missions, and rank order correlations between scores made on succeeding operational days by 16 graduate Sperry gunners and 16 graduate Martin gunners (Laredo, fourth quarter, 1944)*

ODD-EVEN ATTACK RELIABILITY COEFFICIENTS

	5 July	11 July	17 July	19 July	20 July	21 July	Average
Sperry tracking	0.76	0.43	0.91	0.86	0.91	0.50	0.79
Sperry framing	.70	.42	.52	.54	.51	.62	.56
Martin circ. error	.55	.81	(1)	.43	.82	.82	.72

DAY AGAINST DAY RELIABILITY COEFFICIENTS

	5 July	11 July	17 July	19 July	20 July	21 July	Average
Sperry tracking:							
7 July	—	0.20	−0.14	−0.49	0.44	−0.26	—
11 July	0.20	—	.37	−.24	.69	.30	—
17 July	−.14	.37	—	.42	.31	.08	—
19 July	−.49	−.24	.42	—	−.58	.20	—
20 July	.44	.69	.31	−.58	—	−.16	—
(Average Rho=0.08)							
21 July	−.26	.30	.08	.20	−.16	—	—
Sperry framing:							
7 July	—	0.04	0.16	.31	0.54	0.34	—
11 July	0.04	—	.44	.36	.26	.41	—
17 July	.16	.44	—	.49	.54	.44	—
19 July	.31	.36	.49	—	.64	.52	—
20 July	.54	.26	.54	.64	—	.40	—
(Average Rho=0.40)							
21 July	.34	.41	.44	.52	.40	—	—
Martin circular error:							
7 July	—	0.41	—	−0.04	0.45	0.26	—
11 July	0.41	—	—	.01	.21	.24	—
17 July	—	—	—	—	—	—	—
19 July	−.04	.01	—	—	−.04	−.14	—
20 July	.45	.21	—	−.04	—	.37	—
(Average Rho=0.13)							
21 July	.29	.24	—	−.14	.37	—	—

[1] Insufficient data.

morale of the gunners, etc., were acting in different strengths from day to day. See table 9.43; Spearman-Brown corrections have not been applied to coefficients here reported.

One instance in which lack of facilities for adequate control of conditions invalidated data derived by means of the gun camera is seen in the air phase of a study conducted by personnel of the Research Division of the Central School in cooperation with the Army Air Forces Board at Orlando, Fla. The ground phase of the project is summarized elsewhere in this chapter and concerned the evaluation of the E-14 Trainer modified for use in training B-29 gunners. In the ground phase a number of subjects were given practice on the device, and curves of learning were plotted.

The air phase was partially an attempt to validate the training received on the ground trainer against gun camera as a criterion of proficiency.[32] Thirty-four subjects, 5 combat bombardiers (Group A), 10 combat gunners (Group B), 9 graduate gunners (Group C), and 10 untrained gunners (Group D), were each given 4 missions in both the ring and blister positions of a B-29. Each mission consisted of 6 simulated attacks by a P-51 airplane, from the 3 o'clock and 9 o'clock positions beginning 1,000 to 1,500 yards out. The bomber flew at an indicated air speed of approximately 200 m.p.h. and at an altitude of approximately 10,000 feet; attacks conformed to the pursuit curve pattern as closely as possible. The report (published by the AAF Board) does not indicate the lapse of time between missions, the method of alternating the subjects from one position to the other, whether the right or left blister station was used, or the alternation if both were used.

The film, exposed through the sighting heads, was scored for tracking error and framing error, the former in terms of the mil distance between the center of the reticle and the center of the attacking plane image, and the latter in terms of the mil differences between the wingspan of the plane image and the diameter of the reticle. Shortage of film required that the cameras be run at a slow speed, producing about 60 frames of exposed film per attack. This further necessitated that every fifth frame of film be scored instead of every tenth in order to obtain 10 readings per attack. The report does not mention precautionary measures taken to ensure reliable scoring.

The fact that the scores derived from the gun camera film were of unsatisfactory reliability precluded the drawing of de-

32 Project Officer for this investigation was Capt. Alfred O. Jensen, assisted by Lt. Clarence F. Willey and Sgt. Carl H. Martens.

fensible conclusions from the data obtained. Evidence of this lack of reliability is seen in table 9.44 which gives mission-to-mission correlations obtained from both ring and pedestal sights. The highest of these inter-mission reliabilities was 0.56. No intramission reliabilities, correlating odd versus even numbered attacks, were reported.

Learning as measured by the gun camera.—From the foregoing passage pertaining to reliability and the lack of it in ordinary practice, it can be surmised that under the conditions usually obtained in the gunnery schools there would be little if any evidence of learning on gun camera missions.

One of the studies referred to above (pp. 227) in the discussion of reliability was concerned with the learning evidenced by 32 graduate gunners on 10 successive gun camera missions. Sixteen of these men had been trained on the Martin turret in gunnery school and received their 10 experimental missions in that turret; the other 16 had been trained on the Sperry turret and received their missions in that one. Each mission consisted of 6 attacks per subject, 3 from the 9 o'clock position and 3 from 3 o'clock; all attacks were flown on a pursuit curve. In filming the attacks all cameras were under the control of the instructor's switch, which was closed only during satisfactory attacks.

TABLE 9.44.—*Reliability of gun camera scores: Product moment correlations between scores on single missions and between combined scores on pairs of missions, in terms of tracking, framing, and tracking-plus-framing errors made from pedestal and ring sighting stations (Orlando, third quarter, 1944).*

Mission	Pedestal station				Ring station			
	N	Framing r	Tracking r	Framing-plus-tracking r	N	Framing r	Tracking r	Framing-plus-tracking r
1 and 2	34	0.39	0.54	0.56	34	−0.01	−0.13	−0.10
2 and 3	31	.12	.20	.05	[illegible]	.50	.30	.38
3 and 4	24	.27	.47	.38	16	.53	−.16	.13
1–2 and 3–4	24	.39	.06	.15	16	.50	.01	.42
1–3 and 2–4	24	.39	.63	.46	16	[illegible]	−.11	.37

At the end of the 10th mission the tracking error and framing error scores for Sperry gunners and the circular error scores for Martin gunners were computed and plotted. The data are shown in table 9.45 and the curves plotted from the data are given in figure 9.24.

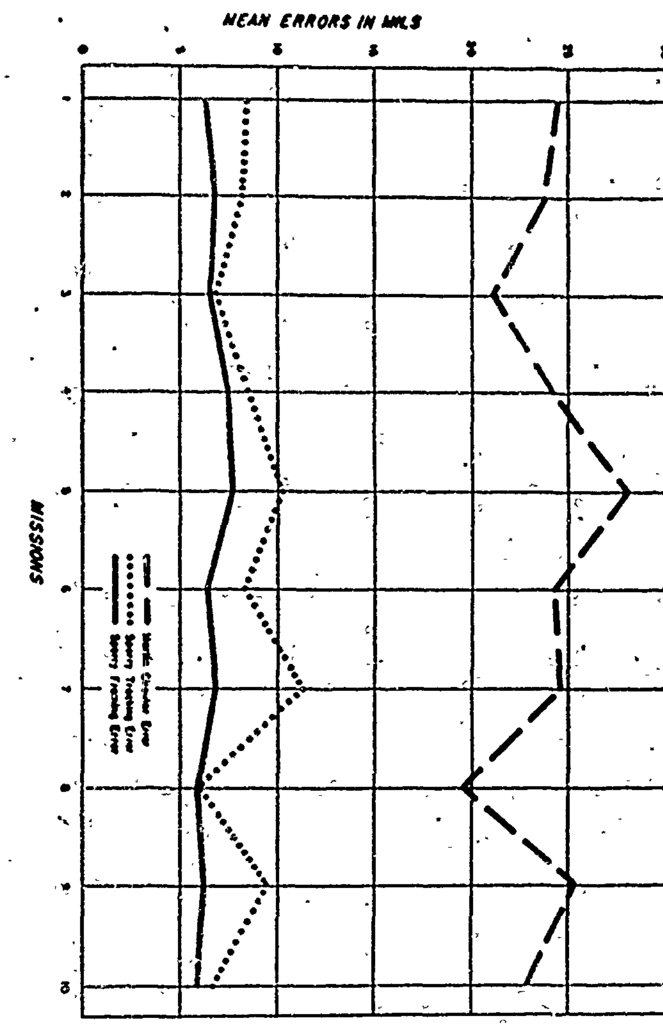

Fig. 9.24 · Mean tracking errors and mean framing errors of 12 graduate Sperry gunners, mean circular error of 16 graduate Martin gunners on 10 successive gun camera missions (Laredo, 4th quarter, '44)

TABLE 9.45.—*The course of gunnery proficiency: mean and standard deviation of mil tracking and framing errors of 16 Sperry gunners and circular errors of 16 Martin gunners on 10 successive missions (Laredo, fourth quarter 1944)*

Measurement	Mission number									
	1	2	3	4	5	6	7	8	9	10
Sperry gunners										
Tracking error:										
Mean	8.42	8.03	6.85	8.48	10.22	8.25	11.22	5.90	9.38	6.65
SD	3.55	2.48	1.82	2.12	4.85	3.18	4.22	1.35	3.38	1.68
Framing error:										
Mean	6.38	6.82	6.58	7.42	7.70	6.45	6.75	5.85	6.02	5.82
SD	3.32	2.20	1.72	4.88	2.78	2.80	2.58	2.52	1.68	2.30
Martin gunners										
Circular error:										
Mean	24.50	23.85	21.15	24.28	28.05	24.35	24.62	19.50	25.32	22.88
SD	5.22	5.48	4.40	4.55	6.75	7.18	5.28	3.85	6.85	5.50

There was no consistent trend of improvement or decline in proficiency in any of the measures excepting Sperry framing, in which case the average error score for the first five missions was significantly worse than that obtained on the last five missions; this difference was probably due chiefly to the poor performance on missions 4 and 5.

The intercorrelations of Sperry framing errors for the 10 missions are reported in table 9.46.

TABLE 9.46.—*Intercorrelations of ranks in proficiency in framing of 16 Sperry gunners on 10 successive missions (Laredo, fourth quarter, 1944)*

	Missions									
	1	2	3	4	5	6	7	8	9	10
1	------	0.31	0.29	−0.03	0.34	0.06	0.42	−0.05	0.59	−0.22
2	0.31	------	.37	.15	.24	.31	.43	.05	.64	.20
3	.29	.37	------	.47	.10	.41	.24	.28	.83	.11
4	−.03	.15	.47	------	.44	.68	.48	.38	.28	.54
5	.34	.24	.10	.44	------	.51	.64	.44	.43	.44
6	.06	.31	.41	.68	.51	------	.82	.60	.53	.64
7	.42	.48	.24	.48	.64	.82	------	.68	.68	.69
8	−.05	.05	.28	.38	.44	.60	.68	------	.27	.63
9	.59	.64	.33	.28	.43	.53	.68	.27	------	.21
10	−.22	.20	.11	.54	.44	.64	.69	.63	.21	------

Considerable evidence of learning was found when the subjects concerned were untrained gunners, as shown in another experiment done in collaboration with the School of Aviation Medicine in October of 1944.

In this experiment, 54 men were selected from the pool of men awaiting entrance into Basic Gunnery School. The only requirements were an Army General Classification Test score of 110 and a record of no previous gunnery experience. The men

were divided into 3 groups of 18 men each and arbitrarily assigned to the Sperry upper turret, the Martin turret and the waist gun position equipped with the K-13 compensating sight, all in YB-40 airplanes; subjects remained at these assigned positions throughout the experiment. Each group was given a lecture on the equipment it would use, and the Martin gunners received an indoctrination in the principles of position firing. The groups assigned to the turrets were given 8 minutes of practice on the Spotlight Trainer, and all 3 groups were given a familiarization flight of about 1 hour. At the conclusion of these familiarization preliminaries the subjects began a schedule which called for them to fly a mission each afternoon and see the results of their firing the next morning when the film of the preceding day was given a preliminary scoring. Each mission for each subject consisted of six attacks, three from 3 o'clock position and three from 9 o'clock. Waist gunners shifted from one gun to the other after three attacks from the first side. The same scores as in the experiment last described were used. In addition, the Sperry gunners received a combined score consisting of the sum of the average tracking error. The score for waist gunners was average tracking error, measured as the distance between the center of the sight reticle and the nose of the attacking plane, since the proper point of aim with the K-13 sight was always the nose of the attacking fighter.

Untrained gunners definitely showed increase in proficiency in the gun camera situation. Table 9.47 shows the means and standard deviations by mission for each group of gunners, and table 9.48 shows the comparisons of the first and last five missions. In each case the product-moment correlation between the two arrays was taken into account in computing the standard error of the difference.

Table 9.49 summarizes the results of a comparison between the performance of gunnery graduates in the earlier experiment and the untrained gunners used in this experiment. Although the data were obtained in different experiments, every effort was made to maintain exactly comparable conditions between the two studies. The results indicated that although the trained Martin gunners made reliably better scores and the trained Sperry gunners made reliably better *framing* scores on the first five trials than did the naive students, no differences appeared between the two groups on these scores on the second five trials. On Sperry *tracking* scores, the naive gunners did reliably better than did the trained gunners both on the first five and second five missions. No explanation of the superiority of the naive gunners on this score was found. There was no reason to believe that selection

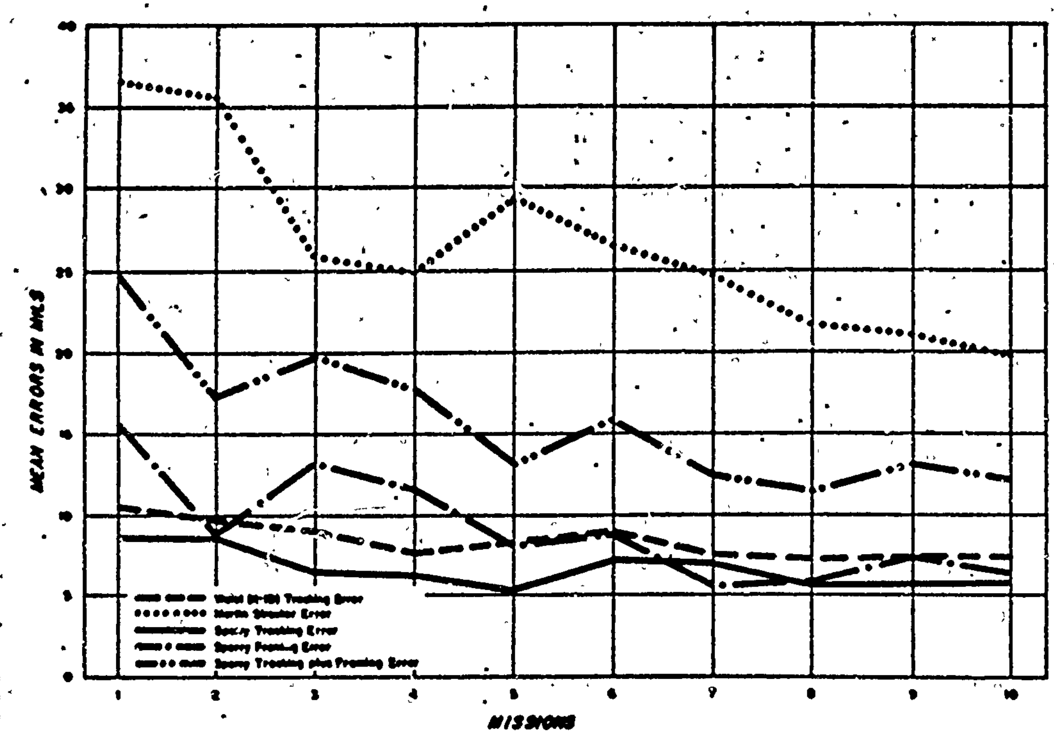

Fig. 9.21 Mean tracking errors, mean framing errors, and mean tracking plus framing errors of 16 untrained gunners in Sperry Upper turret; mean [illegible] errors of 16 untrained gunners in Martin Upper turret; mean tracking errors of 16 untrained gunners at the waist position with [illegible] sight. Measurements in terms of mils for each of 10 missions. [illegible], 4th quarter, '44)

of the untrained group could have affected this difference, or that differences in the firing or scoring procedures could have influenced the results.

Conclusion regarding learning as measured by the gun camera.—The learning situation imposed by the gun camera procedures was not very favorable to improvement. Even in the experiments just summarized, the gunners had no knowledge of results until the morning following the mission, which represented more individual treatment and a higher degree of knowledge of results than was probably possible in large scale training programs; only the naive subjects showed any improvement, and this improvement ceased to be significant after five missions. Although these findings were based on a rather small number of subjects, they clearly suggested that the amount of gain in proficiency to be expected from gun camera training was not great.

Validity of gun camera scores.—There is little that can be said of the validity of the gun camera procedure, except that it was the closest, reliably scorable approximation to combat that was attained in the flexible gunnery program.

For some time a series of attempts were made to increase the realism in the gun camera situation by firing blank caliber .50

TABLE 9·47.—*The course of gunnery proficiency: Mean and standard deviation of mil tracking and framing errors of Sperry gunners, of mil circular errors of Martin gunners, and of tracking errors of K-13 waist gunners on 10 successive gun camera missions, all gunners untrained (Laredo, fourth quarter, 1944)*

	Mission number									
	1	2	3	4	5	6	7	8	9	10
Sperry gunners										
Tracking error:										
Mean	8.48	8.55	6.45	6.22	5.18	7.08	6.90	5.50	5.62	5.72
SD	1.91	2.56	2.45	0.74	0.98	2.21	2.19	1.29	1.08	1.72
N	16	17	17	17	16	17	17	17	16	17
Framing error:										
Mean	15.65	8.72	13.15	11.55	8.10	8.72	5.50	5.90	7.38	6.48
SD	11.41	3.25	4.54	7.03	5.48	5.25	2.07	2.42	2.58	3.20
N	8	17	14	16	15	17	17	17	16	17
Tracking-plus-framing error:										
Mean	24.65	17.28	19.72	17.72	13.22	15.78	12.38	11.40	13.00	12.20
SD	13.26	4.68	4.46	7.26	6.18	5.20	3.08	3.15	3.15	4.31
N	8	17	14	16	15	17	17	17	16	17
Martin gunners										
Circular error:										
Mean	36.55	35.50	25.78	24.88	29.28	26.45	24.72	21.62	21.05	19.75
SD	9.02	15.98	7.82	6.89	7.59	7.49	6.37	5.84	5.04	3.78
N	17	18	12	18	17	18	18	18	18	18
K-13 Waist gunners										
Mean	10.50	9.68	9.00	7.62	8.32	8.92	7.55	7.20	7.28	7.40
SD	2.83	2.92	4.48	2.30	2.44	2.28	1.65	1.62	1.48	1.59
N	18	17	12	17	18	18	18	18	18	17

ammunition during gun camera exercises. Although this combination sounded like an excellent idea at first, it turned out to be replete with difficulties, which greatly impeded its development to the usable state. The principal difficulties seemed to be that the slower rate of fire and the greater recoil of blank rounds combined to produce excessive vibration of the gun, which made it very difficult to obtain clear pictures, and also caused rapid deterioration of gun mounts. Frequent malfunctions were caused by accumulation of carbon in the moving parts and in the recoil booster.

A Frangible Bullet Trainer, described elsewhere in this chapter may be said to have had a higher face validity than gun camera, but the level of development which the frangible bullet technique had reached at the cessation of gunnery training did not permit a score sufficiently reliable for use as a criterion of gunnery proficiency. It is possible that frangible bullet training contained greater motivational possibilities, since it actually involved shooting guns instead of a camera at a target, but there was no quantitive affirmation or denial of this possibility. It is regrettable that no experiment was performed to evaluate frangible bullet training in terms of proficiency with the gun camera.

TABLE 9.48.—*The course of gunnery proficiency: Means and standard deviations, differences, standard errors of differences, and t of mean differences in mil errors made on first 5 and second 5 of 10 successive gun camera missions, in terms of tracking and framing errors of Sperry gunners, circular errors of Martin gunners, and tracking errors of K-13 waist gunners, all gunners untrained (Laredo, fourth quarter, 1944)*

	Sperry tracking	Sperry framing	Sperry tracking and framing	Martin circular error	K-13 tracking
N	17	17	17	18	18
Missions 1-5:					
Mean	6.95	10.80	17.62	30.45	9.08
SD	1.08	2.98	4.02	6.60	2.05
Missions 6-10:					
Mean	6.15	6.75	12.90	22.75	7.65
SD	0.93	2.14	2.35	3.68	1.04
Difference	0.80	4.05	4.72	7.70	1.43
SE_{diff}	0.30	0.74	0.97	1.29	0.36
t [1]	2.68*	5.46**	4.86**	5.97**	3.95**

[1] The number of times in 100 that a value of t as large as each one obtained would be expected to arise by chance is indicated by the following system:

* between 1 and 5 times in 100.
** less than 1 time in 100.

Concluding statement regarding gun camera.—In summary, it seems that the gun camera left much to be desired as a trainer. The reliability was at best lower than might have been hoped and even this was obtained only with great care and by rigid control of the situation, which was not ordinarily achievable in training programs. The nature of the task made it impossible

to have immediate knowledge of results. It was an expensive training situation, affording, for a large outlay of men and material, an amount of aiming practice measured in minutes rather than hours. But whatever its shortcomings as a trainer may have been, the gun camera remained the only usable criterion of proficiency available at the close of the gunnery program.

The Firing Error Indicator

One of the areas of flexible gunnery training to receive earliest and most prolonged investigation was the aerial firing situation. The attainment of reliable scores was the principal problem which was brought into focus by the early policy of eliminating gunners on the basis of scores made in firing at flag targets towed parallel to the firing planes. Early studies showed that air-to-air firing at flag targets had very low reliability, as pointed out elsewhere in this chapter. From the point of view of training, a second and more important problem was that of obtaining immediate knowledge of results of firing. The Firing Error Indicator,

TABLE 9.49.—*The course of gunnery proficiency: Means, differences, standard errors of differences and C.R. of differences between graduate and untrained gunners on first 5 and second 5 of 10 successive missions, in terms of mil tracking and framing, and tracking-plus-framing errors of Sperry gunners, and of mil circular errors of Martin gunners (Laredo, July 1944 and October 1944)*

FIRST FIVE MISSIONS

	N	Sperry tracking	Sperry framing	Sperry Tracking-plus-framing	Martin circular error
Mean (trained)	16	8.[illegible]	7.20	16.05	23.92
Mean (naive)	18	6.9[illegible]	10.80	17.62	30.45
Difference [1]		−1.6[illegible]	+3.60	+1.57	+6.53
SE difference		0.52	0.94	1.41	1.84
Critical ratios [2]		−3.21**	+3.84**	+1.11	+3.55**

LAST FIVE MISSIONS

	N	Sperry tracking	Sperry framing	Sperry Tracking-plus-framing	Martin circular error
Mean (trained)	16	8.28	6.25	14.50	23.28
Mean (naive)	18	6.15	6.75	12.90	22.75
Difference [1]		−2.13	+0.60	−1.60	−0.53
SE difference		0.40	0.77	0.93	1.42
Critical ratios [2]		−5.38**	+0.65	−1.63	−0.37

[1] A plus sign indicates superior performance by the trained groups; a minus sign indicates superior performance by the naive group.

[2] The number of times in 100 that a critical ratio as large as each one obtained would be expected to arise by chance is indicated by the following system:

No asterisk: more than 5 times in 100.
* between 1 and 5 times in 100.
** less than 1 time in 100.

originally developed under a National Defense Research Committee contract as an aid in antiaircraft training, came to the attention of gunnery psychologists in 19[illegible], and appeared to have

promise of becoming a means of attaining both requirements of an adequate air firing situation at one time.

Description.—The Firing Error Indicator, hereafter referred to as the FEI, may be described as an acoustic-electronic device for determining the position of a projectile when it was at its closest point to the target. The device consisted fundamentally of two parts: a transmitter located in the target and a receiving station located in the firing plane.

The transmitter consisted of a small battery-operated radio transmitter whose carrier frequency was modulated through the agency of two microphones by ballistic shockwaves originating from projectiles passing in the vicinity. The nearer the trajectory, the stronger would be the shockwaves incident upon the microphones, and the greater the modulated radio signal recorded at the receiving station.

The two microphones were ordinarily mounted so as to face to the right and left of the gunner as he fired at the target. Their diaphragms were purposely tuned to two different audio frequencies, for example, 1620 and 2400 cycles per second. If the gunner shot on the right side of the target one microphone would receive greater excitation from the bullet's shock wave than the other. The two different excitations were transmitted to the receiving station, which separated them and gave the observer at the receiving station the following information: (a) the position of the projectile relative to the target at the moment of passing (right or left) and (b) the approximate minimum distance of the bullet from the target.

Early tests.—Early experimental models of the FEI were given trial application in aerial firing at Buckingham in the latter part of 1943. These tests were mainly to find out if the equipment was ready for more elaborate evaluation to determine its possible status in the flexible gunnery program. Much unit to unit variability in transmitters was revealed as well as adverse effects of slip-stream noise, and of variability in temperature and air density. After these early Buckingham findings, further developmental work was pursued by the Hoffman Radio Corporation and the California Institute of Technology as contractors of the NDRC, and a much improved version of the FEI was brought to the Central School in the summer of 1944 for further aerial tests.

Experimental evaluations.—By the first quarter of 1945 it seemed worthwhile to attempt to determine experimentally the training value to be derived from including the FEI in the aerial firing procedures. Although the development and refinement of the FEI were not yet wholly satisfactory, the device nevertheless had reached a stage whereat it functioned with high mechanical

dependability and was free from excessive influences of extraneous noise and weather variation. Accordingly, an experiment was designed and carried out to determine if the knowledge of results of air firing as given by the FEI would improve gunnery proficiency as measured by some criterion of known reliability and presumed validity.[33] The experiment was a study of transfer of training in which one group of subjects received aerial firing practice using standard gunnery school targets and another group received the same training but was given immediate knowledge of results via the FEI. The criterion selected was 3 gun camera missions, each mission comprised of 12 attacks for each gunner.

Procedure.—Thirty-two untrained gunners showing a representative distribution of Army General Classification Test scores served as subjects. After an orientation course covering operation of the caliber .50 machine gun, manipulation of the Martin turret, sighting, operation of gun camera equipment, safety precautions, intercom, and an orientation flight, the subjects were given 3 gun camera missions of 12 attacks each per man. These missions were originally intended to serve as pretest and provide a basis for dividing the subjects into 2 equal groups, but unreliability of the scores precluded both considerations, and the subjects were randomly assigned to experimental and control groups.

In the experiment all subjects fired 10 missions from a B-24 airplane and on each mission fired at one pass (attack) from each of four positions: right waist position, left waist position, Martin turret firing to the right, and Martin turret firing to the left. Each subject was allowed 180 rounds per mission. The waist positions were fitted with iron ring-and-post sights and the Martin turret with a fixed (N-6A) optical sight.

In order to simulate a pursuit curve and allow the subjects to apply Position Firing rules, the targets were towed in a course parallel to that of the firing plane, but in the opposite direction. The speeds of the 2 planes were adjusted so that a 2 rad lead was approximately 45 degrees ahead of the firing plane, a 3 rad lead directly abeam, and a 2 rad again at 45 degrees astern. The target was usually towed 10 or 15 degrees above the firing airplane at a minimum range of 400 yards.

During and after each pass the FEI receiver operator informed the subject over the interphone of the results of his firing.

The control group fired exactly as the experimental group did with the exception that they fired at standard gunnery targets

[33] The project officer for this experiment was Capt. James B. Carson, assisted by S/Sgt. Curtis E. Muir. The experiment was designed and the report written by Maj. John V. McQuitty.

4½ feet x 20 feet, whereas the FEI transmitters were mounted in targets 4½ feet x 11 feet. Also, of course, the control group did not receive knowledge of the results via the FEI.

After 10 missions all subjects were given 3 gun camera missions, each consisting of 3 P-63 attacks per gunner fired at from each of the 4 previously identified positions. For the waist positions the film was exposed through K-13 sights and scored in terms of tracking error. The Navy assessing device was used with the Martin turret, which allowed film to be scored in terms of tracking error. All errors were expressed in mils.

Results.—The critical results of the experiment are shown in table 9.50. It is noted that in every comparison but one the control group performed slightly though (probably) insignificantly better than the experimental group (no measures of significance are available).

TABLE 9.50.—*Evaluation of firing error indicator: Mean tracking error scores in terms of mils made from turret and waist positions by experimental and control groups (N = 16 each group on 3 criterion gun camera missions, Laredo, fourth quarter, 1944)*

Position	Mission 1		Mission 2		Mission 3		Total	
	Exp.	Con.	Exp.	Con.	Exp.	Con.	Exp.	Con.
Turret	62.22	54.10	55.25	41.88	56.58	54.22	57.40	50.25
Waist	57.52	57.18	59.40	53.05	55.02	57.75	57.62	55.88

The reliabilities of the gun camera scores appeared to be satisfactory. For waist gunners, an estimated reliability of 0.91 for scores on three missions was obtained by use of the Hoyt method. For turret gunners a reliability of 0.81 for scores on three trials was obtained by computing the correlation between trials 1 and 2 and correcting the resulting value by the Spearman-Brown formula.

No estimates of the reliability of the FEI scores are available at the time of this writing. Representative scores and standard deviations are given in table 9.51.

TABLE 9.51.—*Firing error indicator scores: Mean percent hits (shots passing through bullseye area) and standard deviations for missions 3, 4, 5, and 9 combined, Laredo, fourth quarter, 1944)*

Position	N	M (percentage of hits)	SD
Turret	16	5.95	9.54
Waist	15	5.51	8.85

Only the data from missions 3, 4, 5, and 9 were at all usable, since mechanical difficulties encountered on missions 1, 2, 7, 8,

and 10 rendered their data not comparable to those from the other missions.

Learning apparently did take place on the FEI. Table 9.52 shows a trend, with variations, toward increasing the number of hits scored on successive missions. These data are reproduced graphically in figure 9.26.

TABLE 9.52—*Learning on the firing error indicator: Mean number of hits (shots passing through bullseye area) made from turret and waist positions on each of 10 missions (N= 16, Laredo, fourth quarter 1944)*

Position	1	2	3	4	5	6	7	8	9	10
Turret	0.7	2.6	2.7	2.1	3.3	3.5	2.8	10.2	16.6	9.6
Waist	1.0	2.0	4.0	3.4	2.5	11.5	2.6	13.0	11.1	14.6

Conclusions.—Thus it appeared that the use of the FEI under the conditions of the experiment reported contributed nothing to proficiency as here measured.

Miscellaneous problems of the FEI.—One problem complicating research on the FEI was that of towing the target in a pursuit curve with a minimum danger of shooting down the towing airplane. The method used in the experiment just described was very delicate, easy to invalidate, and required that the sight reticles be altered so that Position Firing rules could be applied.

At the close of work on the project a satisfactory solution to this problem was in the offing. The transmitter was mounted on the nose of a small glider (wingspan approximately 24 feet) which was towed about 300 yards behind and 45 degrees below a B–26 tow plane. The pilot of the tow plane, by maneuvering in pursuit curve fashion about 200 yards higher than he would if he were attacking the firing ship, could make the glider approach the bomber in the desired fashion. Much effort had to be expended in learning just how to take off and land the gliders without crashing them, but the technique proved to be learnable to a fairly satisfactory degree.

During the conduct of the experiment just reviewed, other developments in the FEI were taking place and experimentation with other methods of using the device was under way. The aperiodic system, said to be freer from extraneous influence and more sensitive and accurate than the resonant diaphragm system described in this report, had been brought nearly to a stage of satisfactory development. Plans were being made, but never carried out due to the ending of the war, to evaluate the new version experimentally.

Though fraught with technical difficulties and attendant discouragement throughout its history, the Firing Error Indicator

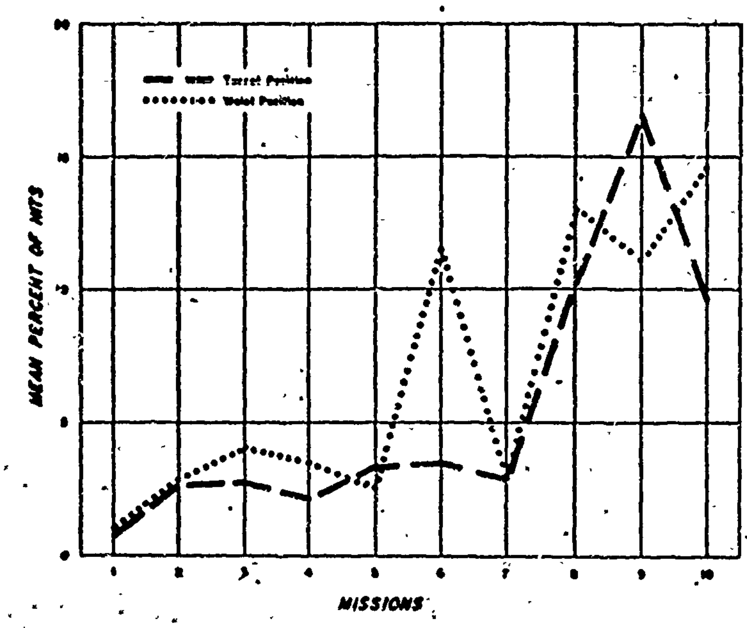

Fig. 9.26 Learning of the Flying Error Indicator, mean percent of "hits" (bullets through bull's eye area) made from turret and waist positions on each of 10 missions (N=16, Laredo, 1st quarter, '45

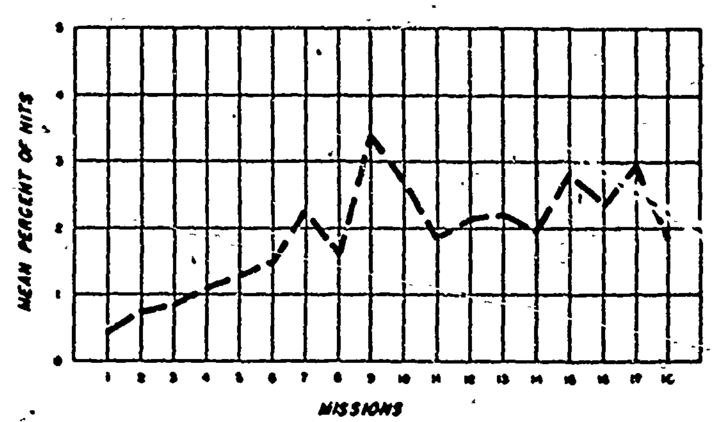

Fig. 9.27 Learning on the Frangible Bullet Trainer, mean percent of indicated hits obtained over series of 18 missions (N=16, Laredo, 3rd quarter '43)

was known to be theoretically sound, and therefore supported the hopes of researchers that some day it would provide the answer to the long quest for an air firing situation which would possess the major requirements of an effective learning situation: realism, analytical and immediate knowledge of results, and reliable scores.

The Frangible Bullet Trainer

History and description.—Probably the most expensive and ingenious attempt to attain realistic flexible gunnery training was represented by the Frangible Bullet Trainer. The idea of a breakable bullet which could be fired at armored airplanes as part of a training program was conceived in 1942. Through the energy and enthusiasm of a small group of persons the trainer approached a stage of practical utility shortly before the close of gunnery training.

During the course of the frangible bullet's development a variety of materials was considered for possible use in the manufacture of the bullets. The principal difficulty encountered was to find a material which the initial shock of explosion would not rupture and which at the same time would not penetrate the armor of the target plane. With the help of the Department of Chemistry at Duke University, the Bakelite Corporation developed a satisfactory caliber .30 bullet made of powdered lead held together by a plastic base. The Bell Aircraft Company produced a large quantity of a special armored version of the P–63 airplane for use in frangible bullet training.

In addition to being heavily armored for the protection of the pilots and vital working parts, the target planes contained shock-activated pickups located just beneath the armor plate at various points; each time the plane was struck, the pickup nearest the point of impact was activated and a mechanical counter in the cockpit recorded a hit. At the same time a light in the nose of the plane flashed on, telling the gunner that he had scored a hit. This description of the counter and light system is rather idealized; in actual practice its functioning left much to be desired.

The policy of the Research Division with respect to new trainers called for evaluation in terms of learning, reliability of scores, and transfer of training before full scale adoption of the devices into the training program. In the second quarter of 1945 the Frangible Bullet Trainer appeared to be ready for such evaluation. A series of controlled flights was planned to derive scores under conditions as nearly constant as possible. The purpose was to

obtain information regarding the course of learning with the Trainer and the reliability of scores derived.[34]

Procedure.—Sixteen untrained gunners were selected at random from the pool of students at Laredo awaiting entry in the basic gunnery course. The subjects were separated into four crews of four men each; each crew was assigned to 1 of 2 YB–40 bombers and did not change bombers throughout the experiment. Each gunner flew 18 missions firing at 8 attacks per mission from the Martin turret which was equipped with a K–15 computing sight specially modified to account for the ballistic characteristics of the frangible bullet. During each attack each subject fired approximately 75 rounds; the instructor announced to the subject the ranges for opening and ceasing fire, 600 and 200 yards respectively. All firing was conducted at an altitude ranging from 7,000 to 9,000 feet with the bomber flying at an indicated air speed of 160 m.p.h. It was originally planned to fly a crew at least every other day, and every day if possible; neither of these objectives was possible, and in some instances as much as a week elapsed between missions due to maintenance difficulties and inclement weather. The experiment extended over 12 weeks, and was attended by loss in motivation and lowering of morale of the subjects.

Results.—The results of the experiment are summarized in table 9.53 and figure 9.27. It is seen that there was evidence of a small amount of improvement during the course of the 18 missions, most of which appears to have occurred during the first 9 trials. The number of hits made on the target planes remained low throughout the experiment; a total of 167,853 rounds was fired and 3,141 hits obtained, or 1.87 percent. The highest percentage obtained by the total group on a single mission was 3.38, and the highest for an individual gunner was 10.

The reliability of scores obtained was not encouraging. The Hoyt estimate of the reliability of indicated hit scores for the total of 18 missions was 0.59, and the average of Hoyt reliabilities for single trials was 0.07. The Hoyt estimate of reliability of scores, in terms of the number of times the light in the nose of the target plane flashed, was 0.52 for the 18 trials combined, and averaged 0.06 for single trials. A product-moment correlation of 0.83 was obtained between indicated hit scores and light scores; if the counter-and-light system in the target planes had been working perfectly this correlation should have been 1.00. It thus appeared inadvisable to use frangible bullet scores to make com-

[34] The project officers for this investigation were Lt. Daniel J. Hilston and Lt. Esten W. Ray.

parisons among gunners regarding their ability to secure hits on the target planes.

Conclusions.—Since there was no evaluation of frangible bullet training against a criterion of gunnery performance, it is, of course, impossible to speak with assurance of the value of the trainer as a contributor to gunnery proficiency. However, if scores had been sufficiently reliable the Frangible Bullet Trainer might have been considered by itself an adequate criterion of gunnery proficiency. It was clear that the trainer suffered from the same difficulty as the gun camera; namely, its lack of efficiency: during the entire experiment, each gunner received a total of about 24 minutes of sighting practice. Although training did provide immediate knowledge of results in terms of hits vs. no-hits, it did not provide information as to the direction or magnitude of sighting errors, which made coaching of students difficult. It may be said, however, that, within limits, the Frangible Bullet Trainer ensured high motivation on the part of students, and offered a possibility for familiarizing students with the various types of tactics in use by the enemy and with ways of combatting them.

MISCELLANY

Special Visual Training Experiment

Mr. Hoyt L. Sherman, of the Fine Arts Department of Ohio State University, had conducted some visual training for the Navy, on the basis of which he claimed to be able to improve the acuity of peripheral vision and the ability to perceive relationships among the components of a whole visual situation. Several interviews with War Department officials convinced them that Mr. Sherman's training method had implications of possible value for training in recognition of aircraft, in scanning and observing, and in aiming. The Buckingham gunnery school was selected as the site for testing Mr. Sherman's proposal.

Description.—For purposes of clarification, the visual training program as prescribed by Mr. Sherman will be described here, and not repeated in the description of the experiment. The training was conducted in a large room approximately 60 by 40 feet in size, equipped with a 12 foot x 12 foot projection screen, a slide lantern with a high speed shutter attachment, drawing stands for 20 subjects, and a phonograph. Each subject was provided with a supply of large size drawing paper and heavy black drawing chalk. The subjects were required to reproduce quickly the forms and patterns which were flashed on the screen at exposures of about 1/20 of a second. The forms were non-

geometric and varied in difficulty of reproduction, embodying changes in size, brightness, number of elements, and plane of projection. The students wore masks which allowed them to see the screen but which prevented them from looking down at their work. As the training progressed the subjects were moved closer to the screen, thus increasing the angle of vision required. Phonograph music was used to encourage the subjects to relax and draw more freely. Twenty-four sessions of approximately 30 minutes each were given to the training. The subjects were divided into 4 sections of 20 men each and took the training at night in addition to the regular training course.

Briefly, it was Mr. Sherman's thesis that his training would enable the gunner better to do two things: first, to perceive each detail of his visual field in accurate relationship to all other details, and to do this very rapidly and automatically; second, to see apparent motion and determine apparent position of planes in his visual field without the need for moving his eyes. Mr. Sherman contended that apparent motion would be most "successfully sensed" without eye movement, via the retinal path of the target's projection, and that the sight field must be held steady in order to "sense the target's tracking pattern."

Experimental evaluation.—The experiment[35] conducted to test Mr. Sherman's training method utilized three groups of subjects. A drawing group, which received the training as described above,

TABLE 9.53.—*Learning on the frangible bullet trainer: Rounds fired, indicated hits, and percent indicated hits made by each of 4 crews of 4 men each, and by the total group of 16 subjects on each of 18 missions, using K-15 sight (Laredo, third quarter, 1945)*

	MISSIONS								
	1	2	3	4	5	6	7	8	9
CREW A[1]									
Rounds fired	2,235	2,340	2,145	2,330	2,375	2,322	2,234	2,400	2,380
Indicated hits	9	7	18	14	33	26	61	14	112
Percent indicated hits	0.40	0.30	0.84	0.60	1.39	1.12	2.73	0.58	4.75
CREW B[1]									
Rounds fired	2,405	2,115	2,255	2,257	2,241	2,368	2,320	2,400	2,043
Indicated hits	9	14	31	33	29	57	44	69	102
Percent indicated hits	.38	.66	1.37	1.46	1.29	2.41	1.90	2.88	4.99
CREW C[1]									
Rounds fired	2,245	2,373	2,300	2,380	2,400	2,372	2,345	2,400	2,363
Indicated hits	17	22	7	25	32	12	57	26	37
Percent indicated hits	.76	.93	.30	1.05	1.33	.51	2.43	1.08	1.57
CREW D[1]									
Rounds fired	2,345	2,370	2,385	2,375	2,338	2,400	2,370	2,365	2,320
Indicated hits	5	26	18	29	25	46	44	44	56
Percent indicated hits	.21	1.10	.75	1.22	1.07	1.92	1.86	1.86	2.41
TOTAL GROUP[2]									
Rounds fired	9,225	9,206	9,085	9,342	9,354	9,462	9,269	9,565	9,086
Indicated hits	40	69	74	101	119	141	206	153	307
Percent indicated hits	.43	.75	.82	1.08	1.27	1.49	2.22	1.60	3.38

[35] Project officer in this experiment was Capt. Mason Haire, assisted by Capt. Theodore R. Vallance and Sgt. Rudolph Goodman.

TABLE 9.53.—(Continued)

	MISSIONS								
	10	11	12	13	14	15	16	17	18
CREW A[1]									
Rounds fired	2,182	2,380	2,319	2,400	2,400	2,400	2,400	2,345	2,390
Indicated hits	131	66	81	51	39	45	38	32	65
Percent indicated hits	6.00	2.77	3.49	2.13	1.63	1.88	1.58	1.36	2.72
CREW B[1]									
Rounds fired	2,270	2,255	2,270	2,255	2,400	2,305	2,375	2,400	2,365
Indicated hits	33	36	41	53	37	76	70	68	40
Percent indicated hits	1.45	1.60	1.81	2.35	1.54	3.30	2.95	2.83	1.69
CREW C[1]									
Rounds fired	2,337	2,400	2,400	2,240	2,370	2,390	2,360	2,330	2,340
Indicated hits	25	35	34	66	54	64	43	76	36
Percent indicated hits	1.07	1.46	1.42	2.95	2.28	2.68	1.62	3.26	1.54
CREW D[1]									
Rounds fired	2,255	2,310	2,354	2,277	2,375	2,368	2,380	2,348	2,320
Indicated hits	54	34	42	32	55	79	71	98	31
Percent indicated hits	2.39	1.47	1.78	1.41	2.32	3.34	2.98	4.17	1.34
TOTAL GROUP[2]									
Rounds fired	9,044	9,343	9,343	9,172	9,545	9,463	9,515	9,423	9,415
Indicated hits	243	171	198	202	185	264	222	274	172
Percent indicated hits	2.69	1.83	2.12	2.20	1.94	2.79	233	2.91	1.83

[1] Crew N's = 4.
[2] Total group N = 16.

was composed initially of 80 gunnery students from class 43–42 at Buckingham. An observation group, consisted of 40 members of the same class; its members attended all of the visual training classes, heard all the instructions and saw the material flashed on the screen, but did not participate in the drawing. A second control group was composed of 40 additional students from the class who were given the pretests and the posttests on the selected criteria only, and neither saw nor participated in the visual training. Members of all three groups were selected at random.

All subjects were pretested and posttested on five criteria as follows:

1. Skeet shooting. This test consisted of 25 shots at the high-house bird from station No. 5 on a normal skeet range. No firing instruction was given the subjects except "You must shoot in front of the bird in order to hit;" all were instructed in how to hold a shotgun and in safety precautions. Approximately 10 men fired on each range, with each man firing 5 shots and then going to the end of the line to await his turn to fire again until he had fired 25 shots. Scores were kept by gunnery school instructors; no score was marked if a man failed to fire.

2. Turret towers. Each subject fired at 20 clay birds thrown from a trap mounted atop a 40 foot tower situated about 50 yards in front of him. The gunner fired from an electrically operated training turret (Crocker-Wheeler) on which was mounted a 12 gauge shotgun. Instruction was given just as to regular gunnery students and scoring was done by the instructors assigned to the range.

3. Jam-Handy (E–14) Trainer. On this motion picture projection type of trainer each subject fired at 16 attacks on a film which showed beam, quarter, and tail-cone attacks. Each subject wore polaroid glasses so that he could not see the projected proper point of aim on the screen. No instruction was given in leading or tracking the target picture. Scoring was done in the usual manner by instructors regularly assigned to the trainer. The test film used in the pretest deteriorated during the course of the experiment and had to be replaced by a slightly different one for the posttest.

4. Speed of identification test. This was a printed test which formed Part VI of the aptitude test for aerial gunners (AC30A). The problem for each item was to select from a group of five plane silhouettes in one column the one which best matched the standard given in another column. The test had 48 such items and a time limit of 4 minutes.

5. Plane formation test. This was a motion picture test developed for the aviation cadet selection and classification program. A grid of 25 squares was flashed briefly on a motion picture screen with 5 airplane silhouettes placed in various positions on the grid. The subject was to reproduce the locations of the planes by marks on a similar grid printed on his answer sheet.

The pretests were administered just prior to the entry of the students into gunnery school. The visual training ran from 8 September to 10 October 1943. Posttests were administered to all subjects on completion of the training.

Results.—Table 9.54 summarizes the order of improvement from pretest to post-test made by each group and presents other pertinent data.

On three of the tests, statistically significant differences were found between groups: On Jam-Handy the drawing and control groups were significantly better than the observation group. On turret tower the observation group was significantly better than the drawing group. On speed of identification, the control group was significantly better than the drawing group. On the other tests no significant differences appeared. Table 9.55 presents all the data of the experiment.

In addition to the five criteria mentioned above, the scores made by all three groups in the aircraft recognition course in the gunnery school were obtained and studied. There were no reliable differences between any of the groups at the end of the course.

Conclusion.—On the basis of the results of this experiment, it was concluded that Mr. Sherman's visual training would not significantly influence performance on the criteria of gunnery

achievement selected for the experiment. While the training may have had value in developing drawing skill, it did not seem to be of practical value in increasing gunnery proficiency.

Aircraft Recognition

Description of training.—Training in aircraft recognition in the flexible gunnery program was conducted according to the "flash" or "Renshaw" method as used generally throughout the Army Air Forces. The training utilized a small slide projector having a variable-speed shutter, which was situated approximately 10 feet from a screen measuring about 3 feet by 4 feet. Typically the training procedure included an introductory long exposure during which the instructor pointed out the distinctive features of each plane. Subsequent exposures varied from 1/5 second to 1/50 second as practice progressed; the instructor named each plane immediately after exposure. In testing situations students wrote the name of the plane after each exposure on an answer sheet and at the end of the period the instructor gave the correct answer after students had exchanged papers.

One of the techniques used in the system was the showing of slides picturing from 4 to 10 digits and slides showing groups of from 3 to 30 objects, which were presented at increasingly rapid exposure speeds. It was the contention of the originators of the system that practice in reproducing the digits and observing the number of "counters" would increase the general efficiency of perception, widen the angle of vision, and greatly increase the ability of students to recognize airplanes seen for only very small fractions of a second.

The digit and counter training has been evaluated at the Psychological Test Film Unit and found to improve considerably the students' ability to reproduce digits and estimate the number of objects presented, but to have no value as an aid in the accurate recognition of aircraft as measured by a slide test and a motion picture test of aircraft recognition.[36]

Influence of seating on test performance.—Not a great deal of work was done by the gunnery psychologists in the aircraft recognition field, particularly after the Psychological Test Film Unit began to devote a large proportion of its facilities to it. One study,[37] however, was made of the relationship between a gunner's location in the classroom and his performance in tests of aircraft recognition. To find answers to this problem, examination scores of five flights of basic gunnery students were examined. The

[36] For further details in this study see report No. 7 in this series.

[37] This study was conducted and reported by Sgt. Ardie Lubin, under direction of Maj. Roger W. Russell.

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TABLE 9.54.—*A summary of results in the visual training experiment: Order of improvement of groups, and statement of the significance of differences obtained*[1] *(Buckingham, September 1943)*

Test	Pearson r, pre- and post-tests	Raw gain, pre- to post-tests	Order of improvement	Significance of improvement differences
Jam-Handy	0.16	−32.3	1. Drawing 2. Control 3. Observation	Observation significantly lower than drawing, but drawing not significantly better than control.
Turret Towers	.12	4.7	1. Observation 2. Drawing 3. Control	Observation significantly better than drawing.
Plane Formation	.55	4.3	1. Observation 2. Control 3. Drawing	No significant differences.
Skeet Shooting	.06	3.3	1. Control 2. Observation 3. Drawing	No significant differences.
Speed of identification	.53	3.5	1. Control 2. Observation 3. Drawing	All differences significant.

[1] All means on the final tests were adjusted for differences in the initial ability of the group. The relation of the initial to the final scores was determined and all groups received corrections in the final means according to their deviations from their initial general mean based on all three groups. In calculating the gain made by each group, the adjusted final mean was compared with the initial general mean rather than the initial mean for each group.

test consisted of 30 slides. The scores were identified according to the locations of the students' seats in a room of 80 seats, and divided into 4 groups of 2 columns (from front to rear) each, and into 5 groups of 2 rows each. The groups are referred to as Column Group A, B, C, and D, and Row Group A, B, C, D, and E.

The approximate average distance of each row group from the screen is given in table 9.56 together with mean scores made on the test.

The following statistical analysis summarizes the findings. Using the method of analysis of variance into four components, the results are shown in table 9.57. The row X column variance turned out to be larger than the error variance. However, the ratio (F) between these variances was 1.82. For 12 and 60 degrees of freedom an F value of 1.92 was required for significance at the 5 percent level. Hence the interaction was not significantly larger than would be expected to occur by chance in a homogeneous population, and the interaction of columns upon rows was not significant. Since the column variance was less than the error variance, it appeared that the position in the row (i.e., the column in which a student sat) had no significant effect upon the scores.

However, the ratio between row variance and error variance

TABLE 9.55.—*Results of the visual training experiment: Initial and final means, variances, gains, reliabilities, and significances of differences between scores for all groups and all criteria (Buckingham, fourth quarter, 1943)*

Group	N	Means: Initial	Means: Adjusted final	Variance: Initial	Variance: Final	Correlation: Adjusted Gain	Correlation: Initial vs final	Reliability of final	F-ratio adjusted final means	Level of significance
Skeet										
Control	38	10.97	15.10			4.5				1% = 4.75
Observation	32	11.78	14.29			3.7				5% = 3.06
Drawing	73	9.81	13.11			2.5				
Total	143	10.56		33.46	21.55		.08	.72	2.4	
Turret tower										
Control[1]	29	9.45	9.85			.4				1% = 6.90
Observation	27	6.22	12.49			6.3				5% = 3.94
Drawing	73	5.81	10.08			4.3				
Total	129	5.94		11.24	10.04		.126	.55	11.5	
Speed of identification										
Control	38	29.1	37.2			10.3				1% = 4.75
Observation	33	30.3	35.5			9.1				5% = 3.07
Drawing	74	24.5	33.8			7.4				
Total	145	26.40		35.62	46.54		.53	.86	4.0	
Plane formation										
Control	38	184.5	182.7			4.7				1% = 4.75
Observation	33	182.4	186.4			8.4				5% = 3.06
Drawing	74	172.7	180.3			2.3				
Total	145	178.0		558.21	381.83		.55	.95	1.1	
Jam-Handy[2]										
Control	35	120.94	104.40			−32				1% = 4.78
Observation	31	141.71	92.53			−43				5% = 3.07
Drawing	73	140.71	103.71			−27				
Total	139	135.90		1023.6	464.65		.16	.85	6.1	

[1] The Control Group was not used in the analysis because it did not meet the test of homogeneity of variance.
[2] The Jam-Handy films for the posttest were different from those for the pretest; therefore, the posttest scores are lower than the pretest scores. The gain score is a negative number.

TABLE 9.56.—*Mean scores made on final test in aircraft recognition course according to mean distance from screen of subjects in each row[1] group (Buckingham, December 1943)*

Row-group	Mean distance (feet)	Mean score
A	12	20.44
B	18	19.63
C	24	18.56
D	30	17.50
E	36	16.31

[1] Each group consists of two rows of students.

was 9.08. The row variance was significantly larger than would occur by chance in a homogeneous population.

Thus it appeared that while distance from the center of the room had no measurable effect on ability to recognize aircraft presented in the course test situation, the absolute distance from the screen (which was determined mostly by the row in which one sat) noticeably influenced performance. These findings are not necessarily at variance with those of the Test Film Unit's study, which reported no significant differences between the 2 groups situated at average distances of 13½ and 26½ feet from the screen. In the study just reviewed Row Groups A and D averaged 18 feet apart, and the test pictures appeared for only a fraction of a second instead of for the much longer time allowed in the motion picture test used as a criterion in the Santa Ana study.

TABLE 9.57.—*Analysis of variance of scores on aircraft recognition test; 400 test scores analyzed for influence of position in classroom containing 80 seats, (Buckingham, December 1943)*

Source of variation	df	Sum of squares	Variance
Rows	4	172.93	[1] 43.23
Columns	3	11.44	3.81
Interaction	12	10[illegible] 87	[2] 8.65
Error	60	285.[illegible]3	4.78
Total	79	574.0[illegible]	

[1] The F-ratio of rows to error variance is 9.08, a value which would be expected by chance less than 1 time in 100.
[2] The F-ratio of interaction to error variance is 1.82, a value which would be expected by chance more than 5 times in 100.

Close-up views as training for long range recognition.—The problem of the transfer from practice on the close-up views ordinarily used in the flash system for recognition of airplanes at combat ranges received some attention at Buckingham. Because of the virtual impossibility of reproducing photographically all the conditions of the perception of distance, no satisfactory slides were ever produced for direct training in the recognition of airplanes at the ranges at which they would ordinarily be viewed in

flight. Mere reduction of the image on the screen and of retinal image size have been shown to be thoroughly inadequate, the size constancy phenomenon operating to stabilize apparent distances despite reductions in retinal image size brought about by moving the viewer farther from the screen.

At Buckingham an attempt was made to produce some slides to simulate 300 yard ranges. A ring representing a 70 mil sight reticle was included in proper proportion to a small picture of the airplane concerned, which appeared to observers to reduce the influence of the size constancy phenomenon to some extent. A complete set of these slides was made and used as part of an experimental curriculum evaluated in a study conducted in January 1944.[38]

Experimental procedure.—On the basis of a pretest composed of 1 close-up and 1 simulated 300 yard view of each of 26 aircraft, 240 basic gunnery students were divided into 2 equal groups. After each plane was introduced to the experimental group, 7 close-up flash views were shown, followed by 7 of the 300 yard views. The control group was given 14 close-up views of each plane. The 20th hour of the course was devoted to a post-test, using, for each of the 26 planes covered in the course, 2 views designed (by the AAF Training Aids Division) to simulate a range of 1,000 yards for viewers seated 15 feet from the screen.

Results.—Variations from the experimental design required the elimination of data on 10 planes on which the number of training views at 300 yards did not exactly equal the number of close-up training views. The post-test data were for 32 items (16 planes). The results, reported in table 9.58 in terms of correct recognitions, show that no transfer from practice on the 300 yard views to recognition of the 1,000 yard views was realized. The results, while showing no difference between the post-test means of the two groups, do indicate a difference in variability significant at the 2 percent level.

Reliability.—Though no data are available on the reliability of scores on the tests ordinarily given in gunnery schools, it seems fair to assume that satisfactory reliability could be obtained if test papers were properly scored. It is unlikely that the method of exchanging papers among fellow students for grading purposes made for high reliability of test scores.

Learning in aircraft recognition.—Learning is known to have been obtained in the aircraft recognition course as given in gunnery schools. After a 10-hour course a mean proficiency of 40

[38] The project officer in this study was Capt. Theodore R. Vallance, assisted by Cpl. Walter Cohen, who made the statistical analysis.

TABLE 9.58.—*Transfer of training from closeup to distant views in aircraft recognition: Pretest and post-test means, standard deviations, differences and critical ratios (Buckingham, January 1944)*

Group	Pretest			Post-test			Post-test			
	M[1]	SD	N	M[1]	SD	N	Difference between means	CR	Difference between— SD's	Difference between— CR
Control	7.52	5.36	120	11.55	4.33	71	0.23	[2] 0.28	1.08	[3] 2.51
Experimental	7.50	4.99	120	11.78	3.15	85				

[1] Correct responses out of 52.
[2] A critical ratio as great as that obtained would be expected to arise by chance more than 5 times in 100.
[3] A critical ratio as great as that obtained would be expected to arise by chance between 1 and 5 times in 100.

percent correct recognitions on a standardized test of 46 slides was attained.[39] The data were obtained from a study of classes 44–39 and 44–37 of the basic gunnery course at Laredo. The recognition course was divided into three parts: Part 1, inline engine planes studied for the first 3 hours; Part 2, radial engine planes, studied the 4th, 5th and 6th hours; and Part 3, twin-engine planes, studied the 7th, 8th, and 9th hours. The 10th hour was devoted to the final test. Class 44–37 was divided into 3 groups of approximately 40 men each; one group took the standardized test at the end of Part 1 of the course, another group took the same test at the end of Part 2, and the third group took the test at the end of Part 3. The test consisted of 46 slides, 15 showing inline, 16 showing radial, and 15 showing twin-engine planes. Of the total of 27 planes studied in the course, the test included 19 planes represented by 2 slides each and 8 by 1 slide. The results of the tests are shown in table 9.59.

TABLE 9.59.—*Learning in aircraft recognition: Mean percent of correct responses in recognition of aircraft at beginning and at various stages throughout the course; data are subdivided according to type of plane, and for total test (Laredo, third quarter, 1944)*

Test number	Inline engines	Radial engines	Twin engines	Entire test
Pretest (Class 44–39)	23	19	19	20
1. Group 1 (Class 44–37)	38	20	20	26
2. Group 2 (Class 44–37)	34	41	20	32
3. Group 3 (Class 44–37)	35	44	44	40

[39] The project officer for this study was Capt. Lee O. Garber, assisted by S/Sgt. Burton R. Wolin.

SUMMARY

Rather than attempt to provide a resume of the work described in this chapter, a table has been prepared which presents in summary form an evaluation of the devices and procedures covered in the chapter, and which also represents an attempt to compare the procedures with one another. The limitations of the methods used to evaluate and compare the various training methods are recognized by the writers, and the table in no way purports to provide definitive and unqualified information. The details of the derivation of the information used as a basis for the ratings may be found in the appropriate sections of the chapter and reference to them should help to amplify and clarify the information in table 9.60.

The rationale of the comparisons and evaluations is as follows:

First, training must have validity. Practice in training must improve skill in the task for which training is given. The value of a trainer in doing this job may be estimated in accordance with the following principles.

1. Training should *transfer* to some measurable criterion of the skill which is the goal of training.

2. *Learning* must occur in training in order that transfer to a criterion be realized.

3. Training should have *realism*—it should resemble the skill which is the goal of training; in general, the closer the resemblance, the greater will be the validity of training.

Second, training should have efficiency. Practice in training should produce measurable results, and should do so with a minimum expenditure of time and effort. In order for training to be efficient the following conditions should obtain:

1. Training should yield *reliable scores* representing students' performance; such scores should not be influenced by weather, power supply, or other conditions aside from the ability of the student.

2. Practice should yield *analytical scores,* revealing the ability of the student to perform the component parts of the training task; component scores are necessary for effective coaching.

3. Training should provide for the *fixation of successful practice* by way of immediate and constant knowledge of the correctness of practice.

Third, training should be administratively practical. In order for training to be administratively practical, the following conditions must obtain:

1. Training should be *economical*—it should not require an excessive amount of instructor or supervisory personnel, and the

mechanical devices used should not require an undue amount of maintenance and repair, costly in time and manpower.

2. Training should be *adaptable* to the changing requirements or conditions of training. Installations should not be so constructed as to cause undue delay or re-design in keeping up with changes in the goal of training.

The table appearing on page 258 lists most of the trainers and training methods used in the flexible gunnery training program since late 1942, as well as several devices considered for use but not adopted. Across the top of the table are the characteristics of devices and procedures considered important for effective training. In the body of the table are words which indicate, in the form of a qualitative relative rating the opinion of a group of officers who have been closely affiliated with gunnery training and gunnery research for periods ranging from 22 months to more than 3 years. Asterisks in the body of the table indicate that no rating was appropriate or that no data were available on which a rating could be based.

The meaning of the terms used to rate each training method on each of the eight characteristics is explained below:

1. *Transfer:*
   - * .... No evidence.
   - Slight .... Some favorable evidence.
   - Doubtful .... Negative results in study.
2. *Learning:*
   - * .... Unknown.
   - Doubtful .... Scores unreliable and gains slight.
   - Probable .... Inferred from transfer to criterion.
   - Slight .... Some change in proficiency observed.
   - Moderate .... Considerable change in proficiency over several trials.
   - Marked .... Much change in proficiency, continued over large number of trials.
3. *Realism:*
   - Slight .... Resemblance only to limited aspects of goal of the trainer.
   - Doubtful .... Some resemblance to the gunner's combat job, but with important differences.
   - Moderate .... Fair resemblance to important aspects of the gunner's combat job, without important differences.
   - Marked .... Close resemblance to gunner's combat job.
4. *Reliability of scores under usual operating conditions:*
   - * .... Unknown.
   - Low .... Most coefficients below 0.60.
   - Moderate .... Most coefficients between 0.60 and 0.80.
   - Satisfactory .... Most coefficients above 0.80.
5. *Information regarding errors:*
   - No .... The score or record of performance does not tell nature of errors in performance.
   - Yes .... Score or record provides information on nature of errors.
6. *Reinforcement of success:*
   - No .... Knowledge of effectiveness of practice not given student constantly during, or immediately following (less than 1 second), practice.
   - Yes .... Student can tell at all times how effective is his practice.

7. *Economy:*

Poor	Extremely expensive.
Fair	Very expensive, but less so than trainers rated poor.
Good	Expensive, but less so than trainers rated fair.
Excellent	Relatively inexpensive.

8. *Adaptability:*

Fair	Rigid and resistant to adaptation, without great effort on the part of many people.
Good	Adaptable with only moderate difficulty.
Excellent	Adaptable with little or no trouble.

TABLE 9.60.—*Summary evaluation of flexible gunnery training devices and procedures. (See text for rationale.)*

Training devise or proceduce	Validity: Transfer	Validity: Learning	Validity: Realism	Training effectiveness: Reliable scores	Training effectiveness: Error information	Training effectiveness: Success reinforcement	Practicality: Economy	Practicality: Adaptability	See page
Reflectone trainer	*	Slight	Slight	Satisfactory	Yes	Yes	Good	Excellent	142
Full scale range estimation	*	*	Moderate	Low	Yes	No	Fair	do	146
RCAF range estimation trainer	*	Marked	Slight	*	Yes	No	Excellent	Good	148
Radar AN/APG-15 T1	*	Moderate	Marked	Satisfactory	Yes	Yes	Fair	do	158
B-29 Manipulation trainer	*	do	Moderate	*	Yes	No	do	Excellent	156
E-8 Spotlight (fixed sight)	*	Marked	Slight	Low	No	Yes	Good	Fair	151
E-8 Spotlight (comput. sight)	Slight	Probable	Moderate	Doubtful	No	Yes	do	do	151
E-14 Trainer	*	*	do	Moderate	Yes	Yes	Excellent	Good	166
Waller trainer	*	Marked	do	do	No	Yes	Fair	Fair	161
DeVry panoramic trainer	Doubtful	do	do	*	No	Yes	Good	Good	185
AAFSAT B-29 trainer	*	Moderate	do	Moderate	Yes	Yes	Excellent	do	177
Aircraft recognition	*	Marked	do	*	Yes	No	do	Excellent	249
Skeet shooting	*	Slight	Doubtful	Satisfactory	No	Yes	do	Fair	191
Basic deflection	Doubtful	Moderate	do	do	No	Yes	do	do	194
High tower	*	do	do	Moderate	No	Yes	Good	do	199
Moving base	Doubtful	do	do	Satisfactory	No	Yes	do	do	195
Giant skeet	*	Marked	do	Moderate	No	Yes	Excellent	do	201
Moving target, hand-held guns	*	*	Slight	do	Yes	No	Good	do	204
Moving target, turret guns	*	*	Moderate	Low	Yes	No	Fair	do	204
Burst control range	*	Moderate	Slight	Satisfactory	Yes	No	Good	Good	206
Poorman range fixed sight	*	Marked	Marked	Moderate	Yes	No	Fair	do	209
Poorman range K-13 sight	*	do	do	*	Yes	No	do	do	209
OQ-3, radio controlled target	*	*	Moderate	*	No	Yes	do	Excellent	217
Air firing	*	Doubtful	do	Low	Yes	No	Poor	Poor	218
Gun camera	*	Moderate	Marked	Moderate	Yes	No	do	Excellent	220
Frangible bullet	*	Slight	do	Low	No	Yes	do	Fair	243
Firing error indicator	*	Marked	do	do	Yes	Yes	do	do	237

NOTE: Asterisk indicates no rating was appropriate, or no data available on which a rating could be based.

CHAPTER TEN

Attitudes and Adjustment of Flexible Gunners

Lt. Arthur L. Irion

INTRODUCTION

Data concerning the attitudes and adjustment of flexible gunners are contained in a number of research reports on the attitudes of guners at various stages of their careers and under a variety of conditions. The data upon which this chapter is based were originally contained in the reports of nine separate studies.

The first of these studies was conducted in March 1944.[1] This report summarized an intensive study of the attitudes and adjustment of 100 returned combat gunners. The specific orientation of the report concerned the use of ex-combat gunners in the flexible gunnery training program, yet much of the data had an important bearing on the attitudes of gunners toward their training, their combat duties, their assignments other than combat, and other issues. Like all studies of returned gunners, this study applied in a strict sense only to the attitudes of men after they had been to combat. Application of the findings in other situations, such as the training which these men received before going to combat, may lack validity, since the data involve the memory of the returned gunner as to what his attitudes were many months previously.

A second study of the attitudes of gunners was conducted in the spring of 1944, using as subjects 100 recent gunnery school graduates. Although considerably less elaborate than the study just mentioned, it was specifically oriented toward the attitudes of gunners concerning their basic gunnery training and toward their attitudes on going to combat.[2]

Three further studies on the attitudes of gunners returned from combat were summarized in a report published by the Office of

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[1] This study was conducted by Dr. Carl R. Rogers, assisted by Capt. Wilbur S. Gregory, Lt. William K. Estes, and Lt. Thomas P. Gallagher.

[2] This study was conducted by Lt. William K. Estes and S/Sgt. Philip L. Gordon, using gunners at Buckingham as subjects. Capt. John A. Valentine prepared the summary report.

the Air Surgeon, Hq., Army Air Forces, in December 1944.[3] In all, data were obtained on 2,474 recently returned combat gunners and 2,659 gunners who had been returned long enough to have been assigned to duty in the training air forces. These studies were concerned with the problems of assignment of returned gunners, and with attitudes of returned gunners toward a second tour of combat duty.

Additional data were secured as relatively incidental portions of three studies of gunners in combat.[4] These studies had the disadvantage of dealing with relatively small numbers of individuals, but their results were important as being the only data which were obtained in the combat situation.

A study which compared the efficacy of two training programs in a gunnery school also furnished some additional data on the attitudes of gunnery students toward their training.[5]

The data presented in this chapter deal with attitudes of flexible gunners toward various aspects of the gunnery situation. Attitudes toward gunnery, gunnery training, combat gunnery, and reassignment after combat have been measured in groups of precombat and postcombat gunners. Also presented are certain other attitudes such as attitudes toward the civilian war effort and attitudes toward the reasons for and the necessity of war. Because the attitudes of postcombat gunners were likely to reflect their combat experiences and their psychological reactions to combat, basic data on the gunner's adjustment in, and following, combat are presented.

PRECOMBAT PROBLEMS

The Gunner's Attitude Toward Being a Gunner

Attitudes before going to combat.—Several of the studies listed above dealt with the attitudes of the gunner toward his role as a flexible gunner. These studies revealed, in general, that gunners found the gunnery assignment to be an acceptable one. For example, 100 gunners, graduating from gunnery school, expressed their degree of satisfaction with being a gunner as indicated in

[3] The studies upon which this report was based were conducted under the supervision of the Psychological Division, Office of the Surgeon, Headquarters, AAF Personnel Distribution Command; Psychological Division, Office of the Surgeon, Headquarters, AAF, Continental Air Forces; and the Central School for Flexible Gunnery, AAF Training Command.

[4] Maj. Roger W. Russell studied gunners in the 8th Air Force, Capt. Wilbur S. Gregory studied gunners in the China-Burma-India Theater, and Capt. Mason Haire studied gunners in the 7th Air Force. These studies were conducted in the spring and summer of 1944.

[5] A survey of attitudes of gunners toward their training was part of an experimental evaluation of a special 8-week curriculum (see chap. 11). This study was planned and carried out by Lt. William B. Schrader, Lt. Thomas P. Gallagher, and Sgt. Alexander N. Levine, under the general supervision of Capt. Lee O. Garber.

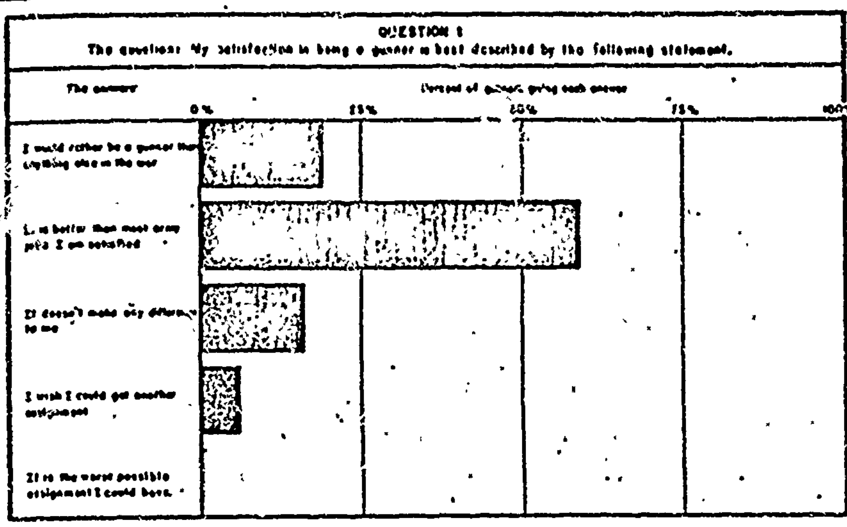

Fig 10.1 – Satisfaction of gunners with their job, percent of gunners answering the indicated question with various degrees of satisfaction (N=100, Buckingham, April '44)

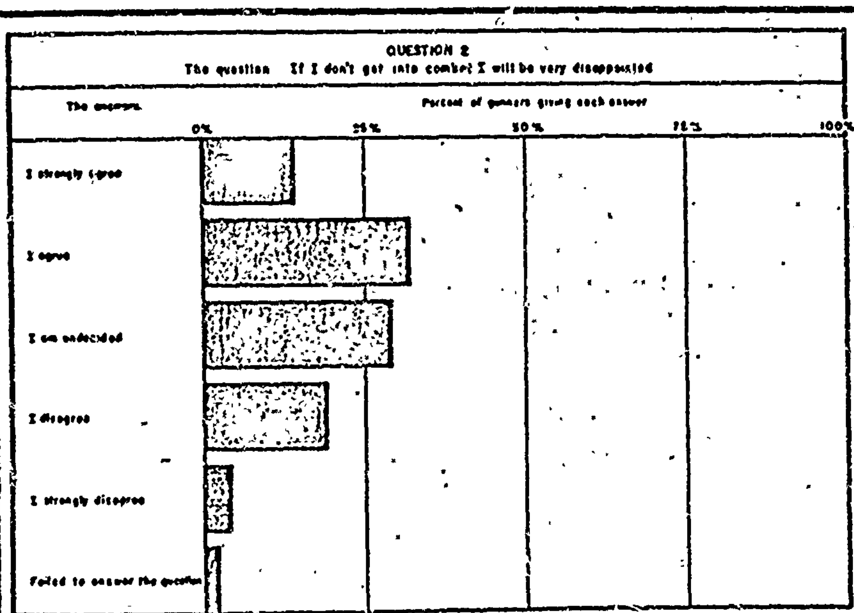

Fig. 10.2 – Attitude of gunners toward combat, percent of gunners expressing various degrees of agreement with indicated statement (N=100, Buckingham, April '44)

figure 10.1. Of this group, 73 percent agreed with the statement, "I believe I would make a good gunner," whereas only 3 percent disagreed with the statement. However, 23 percent were unable to make the decision. The majority of this group also indicated a desire to fly and a desire to handle and study guns. The great majority (81 percent) indicated a belief that the gunner's task was as important as any other job in a bomber. This attitude, favorable to gunner as a military assignment, seemed to become increasingly favorable during gunnery training. Of 100 gunnery students who were interviewed before and after attending flexible gunnery school, 69 percent indicated a desire to become a gunner before attending school, while 85 percent indicated this desire after completing gunnery training. Before training, 12 percent of the students did not want the gunnery assignment, while after completion of training only 3 percent were not desirous of becoming gunners.

Attitudes after combat.—The attitudes of the gunner toward his role, in so far as this role involved combat duty, seemed to undergo a marked change as the gunner went from the zone of the interior to combat and returned again. This could not be determined with complete certainty from the data which were available, since these dealt with different groups of gunners in pre-combat, combat, and post-combat investigations. There may have been, therefore, various selective factors operating to produce the results which were obtained. Nevertheless, the data are presented, subject to this limitation.

Recently graduated gunners expressed their attitude toward combat as indicated in figure 10.2.

Again, the 100 gunnery school graduates answered the following question as indicated:

QUESTION 3. *After I have completed the required number of combat missions, I would like to be treated as follows:*

10 percent answered:	I would like to volunteer for additional missions as long as I feel fit to fight.
43 percent answered:	I would like to be given a rest before returning to combat.
16 percent answered:	I would like to be assigned to noncombatant duties either overseas or in this country.
23 percent answered:	I would want to take any assignment they could give me in this country.
8 percent	Failed to answer the question.

As will be noted, slightly over half of the recently graduated gun-

ners expressed some willingness for combat in excess of a single tour of duty.

When over 5,000 returned gunners were asked to express themselves on a similar question, only 15 percent indicated a favorable attitude toward return to combat, although an additional 16 percent indicated an indifferent attitude. In this case, the question and answers were as given below:

QUESTION 4. *How strong is your desire to return to combat as a gunner?*

5 percent answered:	Very strong desire to return.
10 percent answered:	Some desire to return.
16 percent answered:	Indifferent as to returning.
27 percent answered:	Some desire not to return.
40 percent answered:	Very strong desire not to return.
2 percent	No response.

As a further check on the attitude of returnees toward a second tour of combat duty, 1,750 returned combat gunners were asked to indicate a choice between returning to a second tour of combat duty or being assigned to the duties of a basic soldier. Even though assignment as a basic soldier would have involved loss of prestige, loss of flying pay, and possible loss of rank, the majority of returned gunners (55.4 percent) preferred this status to a second tour. Furthermore, of 2,659 returned gunners, 81.4 percent indicated that they did not plan to volunteer for a second tour of combat duty.

Approximately 2,500 returned gunners were asked to give their reaction at the time they first learned that they had been assigned to gunnery training. Their responses are indicated in figure 10.3. These same 2,500 returned combat gunners were asked to give their reaction to the prospect of combat, after having completed training but before going on their first mission. Their responses are given in figure 10.4. The results obtained from the study of the attitudes of ex-combat gunners which indicated that they had been satisfied with the gunnery assignment and relatively eager to go to combat were in agreement with the results obtained from precombat gunners (questions 1 and 2). In view of the attitude of ex-combat gunners in rejecting a second tour of combat duty, these data served to substantiate the conclusion that a shift in attitude from relatively favorable to relatively unfavorable toward combat gunnery did occur as a result of combat experience.[6]

On the basis of the data presented above, it was concluded that

[6] This problem is further discussed in pages 279 to 281 following.

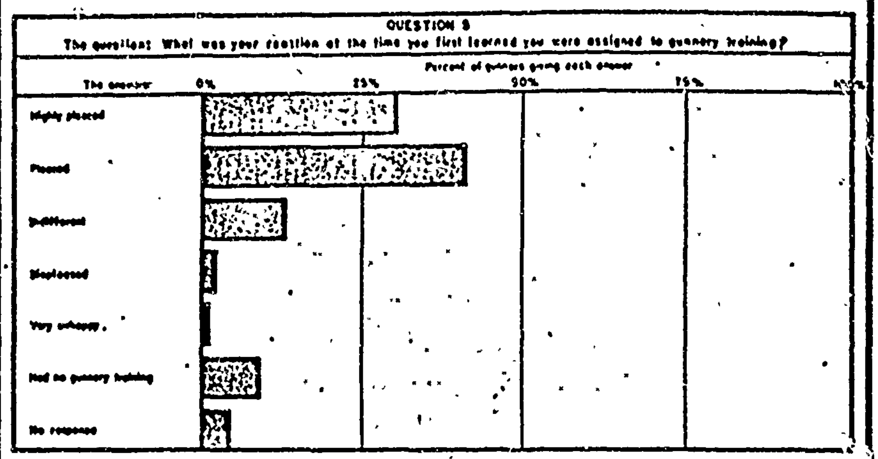

Fig. 10.3—Attitude of ex-combat gunners toward having been assigned to gunnery training (N=2659 gunners assigned to training air force stations, latter half, '44)

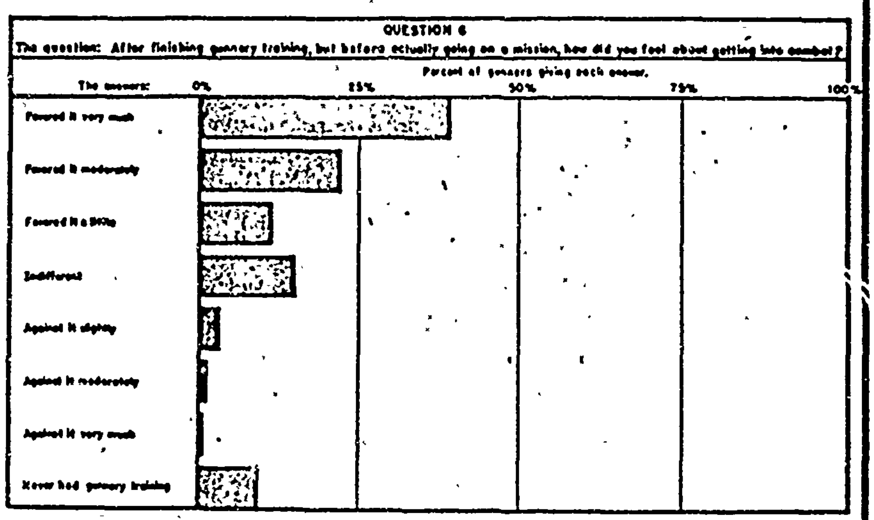

Fig. 10.4—Attitude of ex-combat gunners toward having been assigned to combat gunnery (N=2659 gunners assigned to training air force stations, latter half, '44)

gunners were typically satisfied with their role in the war. It appeared, however, that whereas precombat gunners tended to desire combat experience, ex-combat gunners were reluctant to return to the combat situation.

The Attitude of the Gunner Toward His Training

Relatively little evidence was obtained on the gunner's attitude toward his training and equipment. A study of the attitude of 100 graduating gunners indicated a favorable attitude toward the training which they had just received.

QUESTION 7. *I feel that my gunnery training has been:*

31 percent answered:	The very best training possible.
55 percent answered:	Good, but it could have been better.
7 percent answered:	Just fair.
4 percent answered:	Insufficient.
0 percent answered:	Downright poor.
3 percent	Failed to answer the question.

In another study, psychologists interviewed 100 gunnery school students and rated the students' attitudes toward gunnery school. The interviewers rated 25 percent of the students as having a very favorable attitude, 65 percent of the students as having a favorable attitude, 10 percent of the students as having somewhat unfavorable attitudes, and none of the students as having definitely unfavorable attitudes toward gunnery training. These 100 gunners were also asked to make suggestions for the improvement of gunnery training. These suggestions are contained in table 10.1.

TABLE 10.1.—*Suggestions made by 6-week gunnery school students for improving gunnery training (N=100, Laredo, January 1945)*

Suggestion	*Frequency in percent*
Flight line:	
Reduce lost time	14
Improve equipment and maintenance	11
Increase flying time	6
Improve attitude of instructors	2
Turrets:	
Teach different turrets	7
Reduce time on theory	5
Standardize model on tail turret	3
Reduce time on turret drill	10
Weapons:	
Increase time on malfunctions	13
Increase time on nomenclature	9
Reduce repetition of armament school	7
Sighting:	
Increase training	12
Reduce confusion in instruction	6
Standardize sighting methods	6
Synthetic trainers reduce time on E-14	7
Ground ranges:	
Increase time	5
Improve attitude of instructors	2

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These results are presented in contrast to the results, presented in table 10.2, which were obtained from 54 gunners in the 14th Air Forces. It will be noted that the gunners in combat gave more specific criticisms of training than did the gunners in the zone of the interior. Combat gunners in the 5th and 13th Air Forces were also more critical of the general adequacy of the training which they had received. Each of 50 gunners were asked to state whether or not he felt that the training he had been given had qualified him for combat. Of these, 36 percent answered, "yes;" 28 percent answered, "no;" and 2 percent answered, "don't know." However, 34 percent of the gunners gave no response to the question.

TABLE 10.2.—*Percent of gunners indicating deficiencies in various aspects of gunnery training (N=54, 14th Air Force, June 1944)*

Aspect	*Percent expressing deficiency*
1. Difficulty in manipulating turret and tracking smoothly while firing live ammunition in the air	54
2. Inability to operate other turrets on plane in addition to one on which gunner was trained in States	26
3. Lack of knowledge regarding preventive maintenance and correction of turret malfunctions	24
4. Lack of understanding of principles of sighting (where to aim) against attacking fighters	15
5. Problems arising from formation flying (zone of search, zone of fire, firing without hitting other ships in formation, etc.)	13
6. Lack of proficiency in working on guns in turret	11
7. Lack of knowledge regarding care and cleaning of guns	9
9. Inability to recognize naval vessels	7
8. Lack of skill in adjusting headspace	7
10. Lack of knowledge of principles of sighting (where to fire) in ground strafing	6

These attitudes were somewhat similar to those expressed, in a different type of situation, by 2,659 gunners who had returned from combat. These men answered the following question in the manner indicated:

QUESTION 8. *In which one of the following fields of gunnery do you think you could have benefitted most by additional training before being sent into combat?*

58 percent answered:	Air-to-air firing.
9 percent answered:	Turret operation.
8 percent answered:	Sights or sighting.
3 percent answered:	Parachute and escape procedures.
3 percent answered:	In no fields.
2 percent answered:	Range estimation.
2 percent answered:	Machine gun ground firing.
4 percent answered:	Other (as listed by the gunners).
10 percent	No response.

As was pointed out in one of the original reports, however,

A reservation should be made in interpreting the opinions of the gunners themselves, since they may not be able to judge the type of training that will give them the skills which they want. For example, the frequently expressed need for more air-to-air firing reflects a desire to become more proficient in air firing, rather than an understanding of how skill in this vital aspect of gunnery can be attained.

On the whole, it can be stated, on the basis of the available evidence, that gunners typically felt the training program to be adequate as a whole, but that they were also critical of some aspects of it. The critical attitude toward the adequacy of training was most clearly expressed by the gunners in terms of specific constructive suggestions for the improvement of training. That these suggestions were most clearly formulated by combat gunners and returnees was probably a function of the practical test to which their gunnery skill had been put. The returnees typically felt that the training program was less adequate in the phases which dealt with manipulation of turrets and sighting of targets in flight, than in its other phases.

POSTCOMBAT PROBLEMS

The Problem of the Gunners Who Returned from Combat

As the war progressed, the problem of utilizing the skills and experience of gunners who had returned from combat became more and more significant. The problem was significant not only because the numbers of these men increased rapidly, but also because the returnees constituted a group of highly experienced, hence potentially valuable, individuals. Several extensive investigations were made to determine the most effective use to which the talents of combat returnees could be put.

The background of the returned gunner.—In order adequately to understand the problems of reassignment of returned combat gunners, it was helpful to know something of the background of ex-combat gunners, and something of the experiences which these men had in combat and the effects which these experiencs had upon them. The percentages reported below are based upon approximately five thousand cases of returned gunners in the training air forces and in AAF Personnel Distribution Command stations.[7]

The typical returned combat gunner was 24 years old at the time of his return. Two-thirds of the returnees were 26 years of age or under.

Almost all (96 percent) of the returned combat gunners held the rank of staff sergeant or better. (Thus, if assigned as instructors they were likely to rank seasoned instructors, causing resentment.)

[7] Op. cit., Footnote 3.

As a group, and despite their comparative youth, returned gunners were better educated than the average citizen. Of them, 72 percent had 3 years or more of high school and 12 percent had been to college. (A number of men had good backgrounds for instructors.)

Only 20 percent of the gunners were married before their tour of combat duty. However, many of the gunners became married, either while in combat or shortly after their return to this country. Very few (12 percent) of the returnees had any children. (After combat, men wanted to be with their families. Housing at many gunnery stations made this impossible, causing discontent.)

The typical combat gunner who returned had been on between 26 and 50 combat missions during slightly less than 1 year overseas.

More than half (55 percent) of the returning gunners served in B-17 crews. About a quarter were members of B-24 crews, and the remainder flew in medium bombardment aircraft, chiefly the B-25. Approximately three-fourths of the returned gunners had been to combat in the European Theater (England) or the Mediterranean Theater. Earlier in the war, returnees came about equally from these two theaters, but by the latter part of 1944, many more gunners returned from England. (But most of these men would teach gunners who would be assigned to B-24's and B-29's in the Pacific.)

The returnees had typically experienced a considerable degree of danger in combat. Of those returnees who were studied, 20 percent had been wounded in aerial combat, 42 percent were in a plane which crash landed or "ditched," and 8 percent were forced to bail out. Moreover, 20 percent of the returnees had been on missions in which one or more of the other men on the plane had been either killed or wounded. The typical returned gunner reported that approximately half of his close friends were killed, missing, or wounded in combat.

That fear was prevalent among gunners in combat is indicated by the responses of 2,466 returnees studied by pschologists in the Personnel Distribution Command to the question which is given below.

QUESTION 9. *How did the fears you experienced in combat compare with other fears that you have had in your life? The fears felt in combat were:*

1 percent answered:	Never experienced any fear in combat.
9 percent answered:	Weaker than some other fears.
21 percent answered:	About the same as the strongest fear I ever felt in another situation.
23 percent answered:	Somewhat stronger than any other fear.
45 percent answered:	Very much stronger than any other fear I ever had.
1 percent	No response.

In view of the obvious hazards of the combat gunner's life, and the reported intense fears of these men while in combat, it was considered important to ask them how they were able to complete their tour of duty, what it was that kept them at their job. The question and answers are presented below:

QUESTION 10. *After you were assigned to a combat crew, which one of the following reasons was the strongest in keeping you there?*

46 percent answered:	Desired to do a good job and contribute my share.
21 percent answered:	Preferred flying duty to ground duty.
13 percent answered:	Thought it was the best way to strike an active blow against the enemy.
9 percent answered:	Liked the excitement of combat gunnery.
4 percent answered:	Didn't want to let the other members of the crew down by quitting.
2 percent answered:	Preferred the duties because I didn't want to be called a quitter.
2 percent answered:	Wanted the extra money from flight pay.
1 percent answered:	Performed the duties because I was ordered to do so.
1 percent	No response.

The answers to this question agreed with data from other sources which indicated that the most important single force that held the combat crews together was the feeling of group loyalty and the desire to help the squadron accomplish its mission. This was, for example, in agreement with the findings of Rogers who stated the hypothesis that a high degree of security in a social group was one important source of psychological strength in combat. Grinker and Spiegel[8] also stress the importance of the ability of the gunner to identify himself with his social group: his crew, his flight, his squadron, and so on. The following statements of returned gunners were selected by Rogers as being indicative of a high degree of identification with the social group and of the support which the group, in turn, lent to the gunners.

You felt very close to the crew and would feel "If you can do it, God damn it, I can too!" You don't want to let the crew down. After you have been on a tough trip like Hamburg, Kiel, or the first Schweinfurt raid, you feel a sense of pride.

I think 90 percent of the battle its morale. We had a good gang. The other crews thought that we were crazy, we are always having such a good time together.

Other important reasons (as indicated by Question 10) why gunners believed they remained in combat was interpreted as indicating the importance of the desire to fly, the excitement of combat gunnery, and the opportunity which gunnery offered to strike a blow at the enemy.

In summary, it may be said that the typical gunner returning

[8] Grinker, R. R., and Spiegel, J. P. *Men under stress.* Philadelphia: The Blakiston Co., 1945. (chapt. 3)

from the European Theater of Operations was a young man of somewhat greater than average ability and education. He had typically been eager to get into combat. Once in combat, he found the job to be frightening and dangerous. Nearly all of the gunners suffered the loss of close friends in combat. Many of the returnees had been wounded or injured as a result of their combat activities. The chief motivation which kept these men in combat under these circumstances seemed to be intimately related to the identification of the individual gunner with the combat group. Other motives which gunners indicated had been of importance in keeping them in the combat situation were the desire to fly, the excitement which combat gunnery offered, and the opportunity which was offered to strike a blow against the enemy.

The effects of combat upon the gunner's adjustment.—The conditions under which the gunner operated in combat inevitably had the effect of producing psychiatric casualties in a certain proportion of cases. Many of these casualties escaped inclusion in the studies of gunner's attitudes for the reason that the men involved were evacuated to the zone of the interior through medical channels. Of those returnees who came back to the United States through the AAF Personnel Distribution Command stations, however, many were suffering, or had suffered, from some form of psychiatric disorder. Of 2,659 gunners assigned to training air forces stations, a large percentage had suffered from some type of operational or combat fatigue as is indicated in the figures presented below:

3 percent had been sent to a hospital because of operational fatigue or exhaustion.
23 percent had been sent to a rest camp because of operational fatigue.
12 percent had been given one or more furloughs for reason of operational fatigue.
8 percent had been diagnosed as having flying fatigue or operational fatigue, but had received no treatment for it.
21 percent had been sent to a rest camp routinely, not for operational fatigue.
33 percent had never had operational fatigue nor had been sent to a rest camp.

Thus, approximately 45 percent of returnee gunners (in the training air forces stations studied) had suffered from some form of personality disorder as a result of their combat experiences.

Rogers' study indicated that an even higher percentage of combat gunners suffered, at some time, from combat fatigue or some similar disorder. According to the results obtained in his study,

24 percent of the gunners had exhibited severe combat fatigue and 50 percent of them had shown a moderate degree of combat strain.

The persistence of combat fatigue.—The effects of the stresses of combat persisted after the return of the gunners to the zone of the interior. The return of gunners was accomplished under a variety of conditions. Most of the ex-combat gunners returned to this country under the policy of rotation which permitted the gunner to return to the United States after flying a certain number of combat missions. Not all gunners, however, flew the required number of missions, nor was rotation the only reason for return. The 2,659 gunners studied in the training air forces were returned to the United States for the following reasons:

63 percent	Rotation policy; having flown the required number of missions or hours.
20 percent	Returned because of flying fatigue, after completing about the usual number of missions.
5 percent	Escaped prisoner of war or evadee. (Such personnel were returned to the United States immediately by War Department policy.)
3 percent	Wounded in action or injured in connection with aircraft.
1 percent	Returned because of flying fatigue or operational fatigue without completing the usual number of missions.[9]
1 percent	Returned because of illness, injury, or operations not connected with aircraft.
6 percent	Returned for other reasons.
1 percent	No response.

The persistence of operational fatigue, of course, was dependent upon a variety of factors including the kind and amount of treatment, the original severity of the condition, the military assignment of the returnee, and so on. That operational fatigue effects did persist, however, there can be no doubt. In table 10.3 data are presented which show the state of adjustment of 2,659 returnees following their return to this country. It will be noted that the majority of these individuals, in response to a questionnaire, showed at least a moderate degree of combat fatigue as indicated by the frequency of occurrence of the symptoms considered in the study.

[9] This figure cannot be accepted as representing the number of cases of severe operational fatigue since many of the more severe cases may have been evacuated by the Medical Department, or were not assigned to the training air forces.

Similar results were earlier obtained by Rogers in an intensive investigation of 100 returnees. It was his judgment that 12 percent of the returnees showed marked effects of combat strain, that 46 percent showed effects of combat strain, and that 42 percent

TABLE 10.3.—*The adjustment of ex-combat gunners: Percent showing various degree of symptoms of combat fatigue (N=2659 gunners assigned to 28 training air force stations, August-September 1944)*

Question	Percent of gunners answering:		
	Often	Sometimes	Never
Since returning from combat, do you become easily exhausted or all tired out?	48.9	43.6	7.3
Since returning from overseas duty, have you felt sick to your stomach or felt that you had to vomit?	12.4	45.8	41.6
Do you find it difficult to concentrate on tasks that didn't bother you before you went to combat?	25.5	50.8	23.7
Do you have shaking or trembling hands or knees or muscular twitches?	24.4	51.5	24.1
Since returning from overseas duty, are you easily confused or "rattled"?	16.2	55.6	28.1
Do you worry about things or conditions that you probably can't change anyway?	23.4	53.8	22.7
Do you have fears which seem to drive you out of your mind?	13.7	41.9	44.2
Are you now bothered with sleepless nights?	19.3	52.3	28.3
Are you now restless or not able to sit still?	42.4	45.9	11.8
Do loud or sudden sounds make you jumpy?	40.2	46.1	13.8
Do you feel "blue" or depressed?	21.2	63.6	15.2
Do you become hesitant and so uncertain of yourself that you are unable to make a decision as quickly as you think you should?	15.3	53.9	30.8
Since returning from combat do you have nightmares?	10.0	45.3	43.9

showed little or no effect. These results indicated a slightly greater frequency of maladjustment in the case of those gunners than in the case of the gunners reported in table 10.3. On the whole, however, there is close agreement of the results obtained in the two studies.

Attitudes indicative of combat fatigue.—Rogers gives numerous examples of statements of gunners which show different degrees of combat fatigue. Three of these are quoted from his report; one for a case of severe strain, one for a case of moderate strain, and one for a case of little strain. The attitudes expressed by the returnees in these typical statements show marked differences.

Attitudes illustrative of marked combat strain:

It was a suicide mission, that's what it was. We sent 11 ships from our squadron and 3 got back. I'll never forget that as long as I live! To tell the truth, I still dream of it and when I go around, I'll find myself day-dreaming of it. When I was home on furlough, I slept with my brother and he said

"never again!" because I had so many nightmares. When we got back from that mission and walked out of the plane we couldn't talk! You see planes going down all around you and you just know you're going to be the next.

Attitudes indicative of moderate combat strain:

After 17 or 18 raids you get to worrying more and more because one shell will do it. At first you're glad when you have an easy target, but toward the end, even a raid over France no longer looks easy. You figure one shell will be enough. Toward the end you get more tense on every raid. On the last raid I was most tense of all.

Attitudes indicative of little or no strain:

Of course, I was scared but I got so I didn't worry too much. After a couple of narrow escapes, I felt that if I had come through those, I would probably last for 50 missions. It did make me pray more earnestly and go to church more, though I've always been a good Catholic.

The conditions of combat fatigue.—Rogers also attempted to relate the severity and occurrence of combat fatigue to various other factors such as intelligence, early adjustment, and marital status. In general, few of the factors seemed to be of great importance in the development of combat fatigue, except for the factor of early adjustment. (Early adjustment, in this case, was determined from inspection of case history material. Degree of early adjustment was judged by the same individual who diagnosed current condition, in most cases). Intelligence showed a slight negative correlation with combat strain (that is, the more intelligent gunners were somewhat less likely to develop combat fatigue). Marital status did not seem to be a very important factor although some degree of relationship was established. Early adjustment, on the other hand, had a definite relationship to the presence of neurotic symptoms. This relationship is indicated in table 10.4.

TABLE 10.4.—*The adjustment of ex-combat gunners: Relationship between present neurotic symptoms and preservice adjustment (N=98 ex-combat gunners, Buckingham, January-February 1944)*

Early adjustment	Current neurotic symptoms			Total
	None	Moderate	Marked	
Marked maladjustment	[1] 3 (5.0)	0 (0.5)	3 (0.4)	6
Moderate maladjustment	10 (15.4)	5 (1.5)	3 (1.0)	18
Little maladjustment	71 (63.5)	3 (6.0)	0 (4.6)	74
Total	84	8	6	98

[1] The numbers in parentheses are the numbers which would be found in each cell if pure chance were the only factor operating.

The problem of determining the conditions favorable for the development of combat fatigue was complicated by the fact that a great deal of variability existed in the amount of external stress which was imposed upon different individuals in combat. This, of course, tended to obscure factors of strength or weakness which

may have existed within the individual gunner. On the basis of his investigation, Rogers hypothesized seven factors or sources of psychological strength in combat. These were not considered as factors of demonstrated importance, but only as the best estimate of a qualified observer on the basis of an extensive investigation. Rogers' definitions of these factors, together with his comments about them, are presented verbatim.

1. *A high degree of security in a social group.*—The individual who possesses this characteristic is social, cooperative, loyal to his crew, his team, or his group, forms strong emotional ties to the members of the group, is congenial with them.
2. *A high degree of security in family relationships.*—The man who exhibits this characteristic has strong and congenial relationships with members of his own family—parents, brothers and sisters, and/or wife. While not unduly dependent upon his family, there is a strong sense of support and security, of psychological backing. In some instances, men who show this characteristic do not rate high in the first characteristic—that is, are not particularly social or cooperative. In other instances the man possesses both types of security.
3. *Security in religious faith.*—This, in its psychological effect, is very simiiar to No. 2, above. The man feels a sense of support and psychological backing from the forces of the universe.
4. *Independence.*—This characteristic is shown by the man's economic self-reliance, earning his own way through school, starting a new business, or by a more general willingness to be on his own, to undertake responsible ventures. It may seem that this characteristic is at variance with security in the family and the group. Actually, it is probably the individual who is emotionally secure who is able to be genuinely independent.
5. *Clear purposes and goals.*—It seems to be characteristic of the men who can 'take' combat that they are men who are clear and definite in their personal purposes. This was found to be evident in ability to make choices, in definiteness of post-war plans, in clarity of vocational purposes, and the like. It probably extends to clear views as to the reasons for fighting the war, but our data do not cover this.
6. *Superior ability.*—As has been previously mentioned, there seems to be a slight but definite tendency for the man of superior ability, as measured by the Army General Classification Test, to withstand combat better than the man of lower ability. There is, of course, much overlapping, but the mean score for the group showing little strain is 123, for the group showing much strain is 116.
7. *Constitutional stability.*—Many of the gunners who withstand combat show a tendency to be more stolid physically than the combat strain group. They do not react easily to emotional stimuli, are not excitable.

It was concluded in Rogers' study that:

These are the traits of patterns which seem to characterize the group showing few effects of combat. Not every trait is possessed by every individual, but it would seem possible to say that any man showing four or five of the above characteristics would almost certainly go through combat with a minimum of strain. Measures could be devised to test these qualities with a view to testing and improving the hypotheses which have been stated.

There were, of course, many cases which did not seem to fit any of these hypotheses too clearly. Rogers, in pointing this out, cited the case of an individual who had a long history of inferiority feelings, especially concerning his parental relationships. He never made a satisfactory adjustment, prior to entering military service, and had failed to pass the Instructor's Course, following his return from combat. Yet of his combat experience, he said:

Overseas I felt fine. I was scared all the time, but I felt I wasn't dependent upon anyone. And then my parents were proud of me. I had more peace of mind over there than I have had since my return. Over there you only worried about whether you would be killed. Everything seemed so damned simple.

Although exceptions did occur, it seemed that a selection of individuals on the basis of the characteristics found to be most closely related to the ability to withstand combat strain would prove to be profitable, though errors in selection for combat effectiveness might be made in some cases.

In summary, as a result of their combat experience, a large percentage of combat gunners developed some degree of combat fatigue or allied disorder. These psychological disorders persisted after the gunner had returned to the United States. Rigorous statistical evidence was not available to aid in determining individual characteristics conducive to the development of maladjustment in combat. Rogers' seven hypotheses are presented as being estimates of a qualified observer as to what these characteristics might be.

The Problem of Reassignment of the Returning Gunner

The returned gunner represented an unusual and difficult assignment problem. His prestige, rank, and experience qualified him for positions of responsibility and made him a potentially valuable individual for many types of assignment. On the other hand his rank and prestige were often out of proportion to his ability. Furthermore, the effects of combat upon the returned gunner were often such as to lower his efficiency, to make him less willing to undergo the rigors of military discipline, and to render him unfit for certain types of assignment.

Attitudes toward the returned gunner.—The reaction which the returnee caused in many zones of the interior stations was definitely unfavorable. Representative comments from officers who dealt with these men were taken from interviews or correspondence, and are quoted below:

The problem of discipline is indeed serious. Most of these men feel that because they have been in combat, the world owes them a living.

Many of these men have created problems. In the first place, many did not desire to become instructors and still do not. They came here with a "chip on their shoulder."

Personally, I have felt that some of the combat men were on the verge of becoming psychopathic cases.

On the other hand, some of the attitudes expressed toward ex-combat gunners were extremely favorable, as for example:

This station has received a number of men who have returned from combat duty. These men have done a remarkable job of adapting themselves to their new surroundings and in general it is felt that they are making a major contribution to our program.

In view of the complaints and contradictory attitudes of those to whom the returned gunners were assigned for duty, several investigations were undertaken to determine the returnee's attitude toward reassignment.

Attitudes of returnees toward reassignment.—Probably because no effective assignment policies were in effect at the time when the first of the ex-combat gunners returned to the United States, many misassignments were made in the early period. This had the effect of producing dissatisfaction among the returned gunners, which in turn, very probably led to the commonly expressed opinion that returned combat gunners felt that they had done their part towards the winning of the war and that for them the war was over. The findings of Rogers' study in which the attitudes of 100 returned gunners were determined indicated the incorrectness of this view. According to the results of this study, the overwhelming majority of returning gunners indicated a desire to work at a significant job in the army. Forty-five percent of the group studied indicated a strong desire to contribute to the war effort by working on an important assignment, while an additional 43 percent indicated a moderate desire toward the same objective. Only 11 percent of the group studied conformed to the expressed opinion that ex-combat gunners did not desire to continue their contributions to the war effort.

However, when the returnee was placed in a specific assignment, his satisfaction with that assignment had a tendency to be low. This was partly a result of poor assignment policies. In Rogers' study of the assignments of 100 returned gunners, competent interviewers judged that 60 percent of the individuals studied were poorly assigned. Hence, it was not too surprising when the same study revealed that 68 percent of the ex-combat gunners were at least moderately resentful of their current assignments. It was suspected, however, that in addition to simple malassignment, other factors were operating to produce dissatisfaction. Although the returnee had a definite feeling that he wanted to contribute his knowledge and skill in some way, he was apt to be inclined to insist upon his own definition of the conditions under which that contribution was to be made. In addition, it was likely that many returnees favored reassignment in a general sense, but were unable to face a specific assignment with much satisfaction. There was obtained, nevertheless, a marked correlation between the assignment adequacy and the attitude toward the assignment, as is indicated in table 10.5. This correlation may be, in part at least, a function of method in that the same observers determined both adequacy of assignment and the returnee's attitude toward assignment.

The assignment situation seems to have shown an improvement by the time the following study of assignment satisfaction was conducted on 2659 returnees at a somewhat later period, who had been given various assignments in the training air forces.

QUESTION 11. *Which one of the following best describes your major duty assignment since you have returned to the U. S.?*

57 percent answered: Instructor on flying status.
21 percent answered: Ground instructor in gunnery, armament, radio, etc.
10 percent answered: Armament, radio, mechanic, etc. (ground duty but not instructing).
3 percent answered: Instructor other than the above two types.
1 percent answered: Clerical or administrative.
0 percent answered: Public relations.
1 percent answered: In hospital.
4 percent answered: No assignment.
3 percent answered: Other assignment.

TABLE 10.5.—*The adjustment of ex-combat gunners: Relationship between assignment and attitude toward assignment (N=100 ex-combat gunners, Buckingham, January-February 1944)*

Attitude toward assignment	Very poor	Adequacy of assignment				
		Poor	Average	Good	Very good	Total
Little or no resentment	0	7	2	13	10	32
Moderate resentment	0	22	9	2	1	34
Strong resentment	14	17	3	0	0	34
Total	14	46	14	15	11	100

QUESTION 12. *In your opinion, how well is the Army now making use of your ability and experience other than in combat gunnery, i.e., your military or pre-war experience such as armament, radio, clerical, administrative, etc.?*

25 percent answered: Best use of my ability and experience.
47 percent answered: Good use of my ability and experience.
16 percent answered: Very little use of my ability and experience.
7 percent answered: No use of my ability and experience.
5 percent answered: No assignment has been given to me.

Considering the typical training of combat gunners, the answers to Question 11 seemed to indicate that effective use of the training and experience of these men was being made in their post-combat Army assignments. The answers to question 12 indicated that the returnees felt that, whatever other conditions might obtain, reasonably good use was being made of their capabilities in the great majority of cases.

QUESTION 13. *Which one of the following phrases best describes your satisfaction with your present assignment?*

22 percent answered:	Very satisfactory.
46 percent answered:	Satisfactory.
14 percent answered:	Indifferent.
10 percent answered:	Unsatisfactory.
7 percent answered:	Very unsatisfactory.
1 percent	No response.

The distribution of answers on question 13 was highly similar to the distribution obtained on question 12, and suggested the possibility, as was previously found by Rogers, that job satisfaction was positively correlated with assignment adequacy. This same group of gunners also felt that they were performing in their postcombat assignments in a satisfactory manner, and that their work was of a high degree of importance. These findings are indicated in the answers to questions 14 and 15, below.

QUESTION 14. *How well do you think you are performing the duties of your present assignment?*

5 percent answered:	Outstandingly.
65 percent answered:	Well.
25 percent answered:	Acceptable.
2 percent answered:	Poorly.
1 percent answered:	Very poorly.
2 percent	No response.

QUESTION 15. *Do you feel that your services as a combat gunner are of more value in winning the war than the services you are performing in your present job?*

13 percent answered:	Services as a combat gunner very much more valuable.
10 percent answered:	Services as a combat gunner somewhat more valuable.
35 percent answered:	Services as a combat gunner of equal value to services on present job.
19 percent answered:	Services as a combat gunner somewhat less valuable.
20 percent answered:	Services as a combat gunner very much less valuable.
3 percent	No response.

Some question may arise in the interpretation of question 15. Unquestionably the answers to this question reflected self-instruction on the part of the gunners to a greater extent than in the case of most of the other questions, since answers to the question may have been interpreted by some returnees as a commitment to return to combat. However, it is to be remembered that men

who had undergone the hardships and dangers of combat would probably have been inclined to overevaluate rather than underevaluate the values of their combat efforts. Probably the best interpretation of these data is that the returnees considered their assignments at the time of the study to be of significant importance.

Attitudes toward a second tour of combat duty.—Toward some types of reassignment, however, returnees indicated definite attitudes of withdrawal. Particularly distasteful to the majority of these men was the prospect of an assignment to a second tour of combat duty. Some of the data which indicated the distaste with which returnees viewed such an assignment have been presented earlier in this chapter (pp. 262 to 265). The attitude toward a second tour of duty seemed to have been most greatly influenced by the reactions of the gunner during his first tour. Those returnees in the Personnel Distribution Command stations who experienced the greatest or most frequent fear during their first tour were definitely less willing to return for a second tour than were those gunners who experienced little or infrequent fear during their first combat assignment. These relationships are shown in tables 10.6 and 10.7. Those gunners who had suffered from operational fatigue during their first tour of combat duty also

TABLE 10.6.—*The relationship between strength of fear on the first tour of combat duty and the desire to return for a second tour (N=2466 returnee gunners at AAF Personnel Distribution Command Stations, May-July 1944)*

Strength of fear on first tour [1]	Degree of willingness to return for second tour [2]				
	Very willing	Moderately willing	Willing	Moderately unwilling	Very unwilling
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Never experienced any fear in combat. N = 23	39	22	13	22	4
Weaker than some other fears. N = 242	19	30	22	14	15
About the same as the strongest fear I ever felt in another situation. N = 515	13	31	20	20	16
Somewhat stronger than any other fear. N = 587	9	25	19	28	19
Very much stronger than any other fear I ever had. N = 1099	6	16	18	30	30

[1] In answer to the question: How did the fears you experienced in combat compare with other fears that you have had in your life?

[2] Very willing: Volunteer to return (immediately or after a rest of six months or so).
Moderately willing: No objection to return after a reasonable rest (9 to 12 months) in U. S.
Willing: Willing to return after all trained men still in U. S. have been sent.
Moderately unwilling: Desire to continue noncombat flying, but could not return to combat flying.
Very unwilling: Would prefer nonflying duty in this country.

proved to have attitudes indicating a reluctance to return for a second tour. This relationship is presented in table 10.8.

Minor factors which seemed to have a slight influence upon the

TABLE 10.7.—*The relationship between frequency of fear on the first tour of combat duty and the desire to return for a second tour (N=2469 returnee gunners at AAF Personnel Distribution Command Station, May-July 1944)*

Frequency of fear on first tour[1]	Degree of willingness to return for second tour[2]				
	Very willing	Moderately willing	Willing	Moderately unwilling	Very Unwilling
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Three times or less. N = 396	18	29	18	20	15
About ¼ of the time. N = 332	12	29	22	19	18
About ½ of the time. N = 374	11	19	23	27	20
About ¾ of the time. N = 353	7	21	19	27	26
Almost every time. N = 632	6	21	18	28	27
Every time. N = 362	6	19	17	31	27

[1] In answer to the question: How many times did you feel afraid while flying on combat missions?

[2] Very willing: Volunteer to return (immediately or after a rest of six months or so).
Moderately willing: No objection to return after a reasonable rest (9 to 12 months) in U. S.
Willing: Willing to return after all trained men still in U. S. have been sent.
Moderately unwilling: Desire to continue noncombat flying, but could not return to combat flying.
Very unwilling: Would prefer nonflying duty in this country.

TABLE 10.8.—*The relationship between occurrence and severity of operational fatigue on the first tour of combat duty and the desire for a second tour (N=2466 returnee gunners at AAF Personnel Distribution Command Stations, May-July 1944)*

Operational fatigue	Degree of willingness to return for second tour[1]				
	Very willing	Moderately willing	Willing	Moderately unwilling	Very unwilling
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Did not have operational fatigue. N = 1569	11	25	21	24	19
Operational fatigue with no treatment other than leave. N = 423	7	22	16	29	26
Treated in hospital or rest home for operational fatigue. N = 474	6	17	18	27	32

[1] Very willing: Volunteer to return (immediately or after a rest of six months or so).
Moderately willing: No objection to return after a reasonable rest (9 to 12 months) in U. S.
Willing: Willing to return after all trained men still in U. S. have been sent.
Moderately unwilling: Desire to continue noncombat flying, but could not return to combat flying.
Very unwilling: Would prefer nonflying duty in this country.

willingness of returnees to undertake a second tour of combat duty are listed below:

1. Younger gunners were more willing to return for a second tour than older gunners.
2. Single gunners were more favorable toward return than married gunners.
3. Opposition on less than half of the missions had a slightly favorable influence on the attitude toward return.
4. There was a slight relationship between losses in a gunner's organization and his attitude toward return. Those gunners who had belonged to outfits whose losses were heavy were slightly less willing to return for a second tour.
5. If more than two men were killed in the gunner's plane during his first tour, his attitude toward combat was somewhat less favorable.
6. If relatively few of a gunner's friends were killed on his first tour, he was slightly more favorable toward return than if many of his friends had been killed.

On the other hand, several factors which would have appeared to have significance in the establishment of attitudes toward combat were found to have little actual importance.

1. Enlisted men who were wounded or injured were just as willing to return to combat as others who were not wounded or injured.
2. The number of missions flown on the first tour seemed to have little influence on the attitudes toward return.
3. There was little relationship between the number of combat hours flown on the first tour and attitudes toward return to combat.

In summary, the assignment of the first returnees did not seem to have been as adequately handled as in the case of those who returned later. This tendency toward malassignment had the effect of provoking hostile attitudes on the part of the returned gunners, many of whom were suffering from the persistence of combat maladjustments. The great majority of combat gunners wished to be assigned to significant work upon their return from combat. There was some difficulty, however, for these men in adjusting to specific assignments. On the whole, after the earliest period, returnees received assignments which they felt to be significant and which used their capabilities, at least to a reasonable degree. Most of the returnees at this period expressed satisfaction with their new assignments. Some types of assignment, however, were viewed unfavorably by the returnees. Chief among these was the assignment to a second tour of duty, to which the great majority of ex-combat gunners reacted with a strong negative attitude. Those gunners who had been most frightened on their first tour of duty, as well as those who had been most frequently frightened, were the most reluctant to accept a second tour assignment. A number of other factors had a lesser influence upon attitudes toward return to combat.

Attitudes of the Gunner toward Military Discipline

In connection with a study to determine the feasibility of using combat gunners as flexible gunnery instructors, Rogers made an

investigation of the attitudes of returnees toward military discipline. In his analysis of 100 ex-combat gunners, he found that these gunners unanimously noted the difference between discipline in overseas bases and the more formal discipline practiced on stations in the United States. The returned gunner pictured the overseas situation, with respect to discipline, as being a less formal one; one in which soldiers were motivated toward their duty by a sense of responsibility rather than by a more formal system of command. The returned gunners were in complete agreement that, overseas, the niceties of military courtesy and discipline were greatly minimized. They were almost completely unanimous (99 percent) in regarding this overseas situation, with its emphasis on responsibility rather than on command, as being much more effective in terms of job accomplishment. It was plain that many of them questioned the efficiency of the stress upon formality within the United States. Other returnees, however, believed that a more rigid approach was necessary (in their minds, unfortunately necessary) in this country because of the larger numbers of men, and because purposes and objectives were not as clear in the zone of the interior as they were in combat.

A considerable portion of the men were definitely resentful toward what they regarded as an excess of military formality in this country. Of the 100 men interviewed, 23 percent were found to be strongly resentful, 40 percent moderately resentful, and 31 percent only slightly resentful. In 6 percent of the cases, the attitude toward formal discipline was not determined.

Since these conclusions were reached by means of an unstandardized interviewing technique, no standardized answers were received which could be subjected to a rigorous statistical analysis. However, Rogers listed a number of statements quoted from returnees, which he used to illustrate attitudes of strong, moderate, and little resentment toward the restrictions imposed by military discipline. Several of these statements are quoted below.

Attitudes of strong resentment toward military discipline:

There's a good deal of difference between overseas and here. Over there the officers are more friendly, they're not trying to be better than the enlisted man. The enlisted men are just as important as the officers. Discipline was really better there than here. The men did things because they wanted to and not because they were ordered to. Our first CO was a young fellow, 23 years old, who was later killed. He would play football with us and join right in. We called him by his first name. But when he was with other officers we'd salute him and give him respect. Back here, though, some officers are very petty. I heard one officer bawling out a combat man, pounding on his desk and saying, "This is war!" How does *he* know it?

I don't like this military courtesy stuff. After you come back it makes you mad. I don't want to go through what a rookie goes through. I hate to have some Pfc. barking at you: "You fellows think you're smart because you've been overseas."

Attitudes of moderate resentment toward military discipline:

I believe that an organization can be run more efficiently without a lot of "boy" stuff such as being "gigged" for a match on the floor. After you have been on 50 combat missions, it is hard to see how having an exact order for hanging your clothes is going to kill *another* Jap.

Overseas they respect a man. Here they don't give a damn about him. Over there you salute colonels, of course, but in your own squadron an officer would just as likely as not thumb his nose at you if you saluted him. I don't find it too hard, though, to get back into the system here. The trouble with combat men is that they think they've been through it and are better than anyone else.

Attitudes of little or no resentment:

In my crew there were four officers and three enlisted men. We trained as a crew, and got to know each other here in the States. When we flew, all rank was barred. We slept together, ate together, and the officers stood in the chow line with us. The colonel very often helped serve chow. Everyone did their work and we got along fine. I like that better, but I don't find it hard to get back into camp life here.

In summary, it may be said that the combat returnees who were studied invariably noted the difference between overseas bases and United States bases with respect to the amount of formal military discipline. A very large majority of the gunners resented the imposition of a more formal system of discipline following their return from combat. Almost all of these returnees were inclined toward a belief that a less formal disciplinary system would have been more effectve in terms of job accomplishment. There were, however, no experimental data which bore upon this problem in the military situation.

Attitudes of Gunners toward the War and the Civilian War Effort

Attitudes toward the war.—Although there was conceivably some doubt as to the actual nature of the issues involved in the recent war, the certainty with which the soldiers believed in the cause for which they fought was probably an index of their willingness to participate in the war effort to the fullest extent of their capacity and was probably one of the conditions of their ability to withstand the stresses of combat. Unfortunately, very little was found out about the flexible gunner's beliefs concerning the reasons for the war. The data which were available, however, seemed to indicate that the majority of the gunners had some idea of the importance of, and the necessity for, the war. Whether these beliefs were correct or incorrect, could not, of course, be stated. But the fact of the belief, itself, was important in terms of the soldier's motivation for combat.

One hundred gunnery school graduates were asked, shortly after their graduation from flexible gunnery training: [10]

[10] Op. cit., footnote 3.

QUESTION 16. *As far as I am concerned personally, I am fighting:*

44 percent answered:	For very important and long time goals which I see clearly.
28 percent answered:	Primarily to get back home.
20 percent answered:	For goals that are probably important, but about which I am not too clear.
5 percent answered:	Merely because I have to.
1 percent answered:	Simply because others are fighting; the reasons are not actually clear to me.
2 percent	Failed to answer the question.

These results indicated that nearly half of the gunners felt the importance of the war in terms of specific goals which the winning of the war could help to achieve. Another 20 percent of the gunners felt that the goals were important, and hence that the war was necessary to the welfare of the nation, even though they were unable to formulate those necessities for themselves. Thus, about two-thirds of the pre-combat gunners maintained an attitude which probably tended to increase their morale and willingness to participate in the war effort to the full extent of their ability.

Returned gunners, however, did not seem to have ideas on this subject which were as clearly formulated as were the concepts of the pre-combat gunners. In a study of 100 returnees, Rogers dealt with this problem at a descriptive level. In view of the importance of this subject, Rogers' findings are presented below, in full.

Unfortunately, the question of motivation for war was not made a topic of regular investigation, and the only evidence which was gained is that which came spontaneously. No conclusions can be drawn from the data which follow, but they suggest that for a considerable group, the purposes of the war were not clear, and the motivation for combat was far from satisfactory.

The following comments by the men deserve careful consideration. Some of the men stress their general uncertainty as to the basic reasons for fighting the war.

> I never did figure out exactly what the war is about, and I probably never will.
>
> I don't think either the gunners or the officers have any real idea of what we are fighting for. We are all too remote, I guess. It makes better fighting men to have strong motivation. There was a Polish squadron in England that was just dying to fight the Germans. They had to ration their gas to keep them from crossing the channel to get at the Germans in their little training planes with one .30 caliber gun. When you have a group that wants to fight like that, I think they have fewer casualties than we do.
>
> On furlough I was kind of put out. People go around as though there is no war or anything. Of course, I used to ask myself overseas what I was fighting for and I didn't know, except to get back home alive.
>
> The question of whether the fellows know what they are fighting for is a stickler. They don't talk much about it; they are definitely out to finish it quick and get home. Some of them get pretty cynical as to what it's all about.

A few of the men were cynical or mercenary, or both:

> I'm only 21 years old and at this time rainbow colored dreams don't seem attractive. I wasn't fighting for ideals or democracy, I simply did it for the same reason I joined the Army in peace time. I like guns and I enjoyed combat. I fought for $173.50 a month and nothing else.

The need of helping gunners form clearer ideas as to why they are fighting and what they are fighting for, is all too apparent from these quotations. The material is doubly significant when it is recalled that many of these men were volunteers rather than selectees, and that all of them had volunteered for the gunnery program. It would seem that their motivation might be stronger than that of men now going through the program.[11]

Unfortunately, Rogers was not able to indicate, from his data, the percentage of returned gunners who expressed ideas similar to those quoted above. It appeared, however, that returnees were more inclined to question the basic values of the war than were precombat gunners.

Attitudes toward the civilian war effort.—As in the case of the attitudes toward the war, little evidence was obtained concerning the gunner's attitude toward the civilian war effort. That some dissatisfaction with the civilian war effort did exist, at least among returnees, was indicated by the answers given by 2,659 ex-combat gunners in training air forces stations to the following question:

QUESTION 17. *Which one of the following conditions in the U. S. are you most dissatisfied with?*

31 percent answered:	The attitude of military personnel who have never been overseas.
12 percent answered:	The general attitude of civilians to military personnel.
19 percent answered:	The attitude of labor in this country.
16 percent answered:	The nature of military courtesy, discipline, and training in this country.
6 percent answered:	The attitude of business and industrial management in this country.
2 percent answered:	Rationing.
2 percent answered:	My own family relationships.
12 percent answered:	Not dissatisfied with any condition in the U. S.

These answers indicated a certain amount of antagonism toward the civilian population of the country. That a share of the unfavorable attitudes was related to the gunner's attitude toward the civilian war effort was indicated by the fact that, of the returnees studied, 37 percent were dissatisfied with the civilian population, and of these, 25 percent expressed dissatisfaction with the civilian war effort directly.

[11] This study was made in January and February 1944.

Further evidence of dissatisfaction with the civilian war effort was contained in Rogers' study of 100 returned gunners. He found 11 percent of these gunners to be strongly critical of the civilian war effort, 21 percent to be moderately critical, and 41 percent to be relatively satisfied. Attitudes toward the war effort were not determined in 27 percent of the cases, however. Rogers gives examples of gunners' statements regarding the civilian war effort, four of which are quoted below.

Statements indicative of a strongly critical attitude:

I think the best damn thing we could do is bomb half a dozen towns here! The people don't know there's a war on! If they had seen the people over there—they think they do without things in this country, but if they had seen the people over there! They just don't know how swell it is over here! We take so many things for granted.

At home I went to a football game—I've always enjoyed 'em. But all that life and gaiety and luxury—it just makes you so mad. I never even noticed half the game, I just got madder and madder—even though I know they can't help it.

Statements indicative of a moderately critical attitude:

People are too optimistic. It's going to be long and rough.

My home town seemed very normal. I was not favorably impressed by the free spending and general luxury. Miami Beach was especially disgusting. I think it's a poor place to have men come home.

Although little evidence was available concerning the attitudes of gunners toward the war, it seemed clear that a wide difference in beliefs and attitudes on this subject was to be found among the gunners. There was some evidence to indicate that precombat gunners tended to have had fairly well formulated ideas concerning the reasons for the war and the importance of the issues at stake. The data suggested the possibility that postcombat gunners were in more doubt concerning the reasons for the war, and that the importance of the issues involved was in more doubt among the members of this group.

Attitudes toward the civilian war effort were determined systematically only among returned combat gunners. In this group it appeared that there was a considerable degree of dissatisfaction with the civilian war effort. It appeared, however, that this dissatisfaction was based more upon the complacency of the civilians and their habits of indulgence than upon an actual lack of effort on their part to perform their share of the work of war.

SUMMARY

The typical gunnery school student felt at least a moderate degree of satisfaction with his gunnery assignment. During his training, his attitude toward his status as a flexible gunner tended to become even more favorable. At this state of his career, the gunner was impressed with the significance and importance of

the gunnery task. His motivation for combat was high, both as indicated by his answers to direct questions and as shown by his attitudes toward the reasons for and the necessity of fighting the war. He had, at this time, a favorable and relatively uncritical attitude toward the adequacy of his gunnery training.

Combat experience proved to be frightening and unpleasant for the average gunner. This unpleasantness was firmly based upon objective standards of combat stress, such as the number of friends killed, the number of crew mates killed or wounded, the incidence of wounds and injuries among the returnees themselves, and so on. One result of these combat experiences was that a relatively large percentage of gunners came at some time to suffer from some form of combat or operational fatigue, at least to some degree. The occurrence of combat fatigue, as studied among returnees, seemed to be related to several factors within the gunner as well as to the amount of externally imposed stress. Prediction of combat fatigue could be made most adequately on evidence of precombat maladjustment.

The typical returnees, as an additional and related result of combat experiences, gave expression to attitudes which were somewhat at variance with the attitudes expressed by precombat gunners. The majority of returnees, for example, indicated an aversion to further combat duty whereas precombat gunners typically indicated a desire for combat, even in excess of a single tour of duty. Combat gunners and returnees were also inclined to be more critical of the adequacy of the gunnery training which they had received. This critical attitude, most often, took the form of constructive suggestions which were potentially valuable, with some exceptions, in improving the flexible gunnery training program. There were also indications that the excombat gunners were less sure than precombat gunners of the reason for and the necessity of fighting the war.

Upon returning from combat the average gunner had a favorable attitude toward reassignment to some important duty (with the exception of combat duty, as noted above). There was evidence that the first returnees were malassigned in many cases. This type of malassignment undoubtedly contributed to the attitudes of resentment and hostility expressed by these men. At a somewhat later period, however, returnees were given more adequate assignments. During this period, the returnees indicated attitudes of satisfaction in their new assignments and belief in the importance of their new tasks.

CHAPTER ELEVEN

The Development and Evaluation of Training Programs

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PRINCIPLES AND PROCEDURES

Chapters five through nine of this report have summarized specific research projects which may be presumed to have contributed to the improvement of gunnery training programs. Psychologists in gunnery were directly responsible for giving assistance in the overall planning of training through three different types of activities. The first of these was to give direct assistance to gunnery personnel in the development of training programs, as by outlining curriculums, preparing training manuals, assisting in the development of training aids, investigating instructor-student ratios, and similar activities. This work was broad in scope, more or less operational in nature, and not particularly suitable for detailed treatment in a summary of research. It will not be reported here. The second type of activity was concerned with the formulation of principles which might assist in achieving more consistent, more purposeful training programs. These principles grew out of the application of psychological techniques to specific gunnery problems, and they developed into a common viewpoint as to objectives and procedures, which viewpoint came to be shared by most of the men responsible for planning gunnery training. Some of these principles are reported below. The third type of activity involved the development and evaluation of experimental training programs, and the evaluation of programs in operation. The major part of this chapter is comprised of summaries of such studies.

Diversity of Gunnery Training

Planning for the training of gunners was complicated by two circumstances. First, gunnery changed with great rapidity dur-

ing a brief span of 4 years. Second, there was not one type of gunnery but several. Both of these factors should be examined more closely for they are important in understanding efforts that were made to improve gunnery training.

Changes in gunnery.—Gunnery changed rapidly with the development of new equipment and with the formulation of new procedures for using equipment. Sight and turret combinations changed frequently, only one sight-turret combination remaining standard equipment throughout the war. Early bombers were equipped mostly with hand-held guns mounting iron ring-and-post sights. On later bombers, most hand-held guns were replaced by turret-mounted guns, and the hand-held positions which remained were enclosed and were provided with mechanical sights. Early turrets carried optical sights; later turrets carried mechanical sights. Remote control turrets, incorporating entirely new principles of gunnery, were developed for the B–29. To one position on the B–29, radar aids to aiming were added. Finally, turrets of radically new design, involving gyro-stabilization, were introduced into the B–32 training program. Such changes demanded a continual revision of curriculums, lesson plans, trainers, ranges, examinations, phase checks, films, and film strips.

Types of gunnery.—Not only did gunnery change rapidly with time, but at any one time there were diverse demands on training programs. Superimposed upon a minimum amount of general training for all gunners, there were several specialized training programs for particular types of aircraft and types of gunnery equipment. In training gunners even for one type of airplane, diversity in training was demanded. It was possible, for instance, to have 12 different combinations of sights and turrets on the B–24 airplane. Operation of most of these required different skills. One single position on the B–24 might require the training of four different types of gunners. The Martin upper turret was equipped, in various theaters, with an optical sight, a compensating sight, or one of two kinds of computing sights. The optical sight would require different judgments of deflection; the compensating sight would sometimes require estimations of deflection but on an entirely different basis; one of the computing sights would require framing within vertical lines the wing tips of the attacking fighter by manipulating hand controls; the other computing sight would require framing within a circle of dots by operating foot controls. Such circumstances required that several parallel curriculums be in operation concurrently at the various gunnery schools and even within one gunnery school. At one time, late in the war, there were about 20 courses of study in operation in Training Command gunnery schools. The implications for

program planning are obvious. In a diverse and changeful program, unifying influences were sorely needed.

Unifying Principles

Although the planning of gunnery programs was largely the responsibility of the Central School, and specifically of the Research Division, the total responsibility for the extensive planning and application required could not be delegated to any one group. Commanders of combat air forces, training officers at higher headquarters, commanding officers of gunnery schools, directors of training, department heads, range officers, enlisted instructors, all inevitably had a hand in shaping the training that gunners actually received. It was believed that one of the chief contributions that psychologists could make to gunnery training was the formulation of principles which would lend coherence to gunnery training. In a program so widely scattered geographically, so changing, so diversified, broad principles to guide specific decisions may prove more far reaching in effect than many specific achievements. Principles for guiding the development of training programs as a whole, and principles developed for a single aspect of program planning, the development of training aids, are summarized below. Similar formulations were made for other specific problems, such as the development of trainers. Principles leading to what was considered to be proper emphasis in teaching were also suggested as a final and requisite step toward coherent training.

Principles for program planning. The principles which were considered basic to sound program planning may be stated as follows:

Objectives must be clearly defined.—For sound planning of a program or of a part of a program such as a course, range, or trainer, the objective to be achieved must be clearly defined. The definition of objectives must be made on the basis of a thorough study of the job for which training is to be accomplished, and without reference to entrenched precedent.

Objectives must determine content.—Once agreement has been reached as to what are the objectives of the training program, of the course, range or trainer, everything must be planned to contribute to the achievement of the previously defined objectives. No activity, no material should be included unless it can be justified with reference to the statement of objectives.

Established principles must determine procedure.—When a program has been blocked out, when the content of a course has been determined, when the mechanics of a trainer have been perfected, their organization or use must be based on principles of

learning, drawn from experiments conducted on the specific materials or devices to be used, or from the body of established psychological knowledge.

Content and procedures must be objectively evaluated.—Wherever possible and as quickly as practicable, the effectiveness of a curriculum or of specific parts or a curriculum, such as a range, or trainer, must be evaluated, using objective techniques which have been worked out for assaying the contribution of such variables to the achievement of an objective.

Evaluation should determine revision of content and procedure.—Finally the results of the evaluation of the currriculum, course, range, trainer, must be put to use and not neglected in apathy or in favor of personal prejudices.

The viewpoints expressed in the above statements gained fair acceptance among gunnery personnel, particularly among men most concerned with program planning.

Principles for the preparation of training materials.—In previous chapters the point has been made that gunnery training was always one step removed from the gunner's shooting job, and that substitute training procedures of established validity were lacking. Under such circumstances, there was a tendency to devote much effort to the development of training aids. To give direction to the preparation and use of training aids, the following principles were formulated:

1. No training aid will be used unless it is reasonable to believe that its use will contribute to the achievement of the objectives outlined for a course or for a training program. The fact that a particular training aid is available is not sufficient reason for its use.

2. The materials presented in all training aids must be accurate. Agreement with the Gunner's Information File will normally be the criterion for accuracy.

3. All training aids will emphasize the functional aspects of the gunner's job. They will stress what the gunner actually has to do or actually has to know. Materials on internal operation of sights, on wiring of turrets, on mathematics of sighting will be excluded, along with any other materials not immediately relevant to the gunner's job.

4. All training aids for a particular program will be planned with the planning of the program, and there must be a specific requirement for each training aid growing out of the nature of the training to be given.

5. As a rule, training aids such as motion pictures or film strips will not be used when there is available the actual equipment

which is the subject of the training aid, unless the training aid develops ideas that are not readily apparent through examination of the equipment.

6. Humor in training aids will be used only when it is relevant to the materials presented. Training aids should have dignity, and their effectiveness should not be lessened by the gratuitous addition of humor.

7. Concurrently with the development of every training aid, there should also be developed an instructor's guide for its use. In addition to providing supplementary information for the instructor, the guide should stress the necessity for incorporating the training aid as an integral part of a course designed to help achieve the objectives of the course.

8. For maximum effectiveness, it is believed that there should be maximum economy in the expression of ideas in a training aid. As a rule, a film, a film strip, a poster-series should have one core idea, and every item should contribute to the development of this idea.

9. Where appropriate, as with films, film strips, posters, and pamphlets, there should be constructed a brief objective examination which can be administered to students after the training aid has been used in instruction.

10. Films will normally be used for the presentation of ideas which are difficult to conceptualize, such as the rules of position firing or the methods used by good teachers; the presentation of materials where movement is critical; and the presentation of materials which cannot be shown directly, such as the combat use of the B–29 gunnery equipment.

11. Film strips, posters, mock-ups will normally be used when the detailed study of the materials presented is desired.

12. In all training aids, the very best of writing and the very best of art work will be the goal. Experience has shown that the way to achieve this important goal is clearly to state the requirement in the initial planning of the training aid.

These principles become fairly well accepted, and their value is believed to be evidenced in the generally excellent training materials produced for gunnery training. Priciples for the development of training devices were also formulated. These are summarized in the final paragraphs of chapter 9.

Principles of teaching.—There was an effort made to develop, particularly among instructors and supervisors of training, a consistent viewpoint with reference to teaching methodology. The kind of teaching that is wanted was considered to be important in the original blocking out of a curriculum; such considerations

were felt to be of even greater importance when lesson plans and training materials were being drawn up and when instructors were being indoctrinated. To illustrate, a decision had to be made in gunnery relative to the balance between "practical" and "theoretical" instruction. In the absence of an understood policy on such matters, many and often contradictory viewpoints will influence training, producing an inharmonious, stressful, and probably inefficient program. On this particular matter, it was decided that courses would be stripped of all materials and procedures that were not directly related to what the gunner had to do in combat. Thus instruction in the wiring of turrets and in the internal functioning of turrets and of sights, which were traditional parts of gunnery courses, was dropped; instruction which emphasized being able to talk about gunnery or to pass written examinations was sharply curtailed. Emphasis was placed upon gunners learning by doing the types of jobs they would be expected to do in combat. A functional viewpoint concerning instruction became well established in gunnery.

Procedures in Program Evaluation

Policy in Flexible gunnery with reference to the evaluation of training programs merits consideration. Gradually officers in charge of gunnery training accepted the viewpoint that research must be an integral part of all program planning. Towards the end of the war, no plan for a training program was considered complete unless it included specific plans for establishing the validity of the basic assumptions of the program, for appraising the effectiveness of the program, and for discovering ways in which the program could be improved.

Techniques used in evaluation of specific training programs.—The most incisive technique used in evaluation of training programs was to compare experimentally the achievement of students trained under a new program with the achievement of students trained in traditional fashion, when such comparisons were possible and meaningful. Not only did such studies yield a substantial body of objective data which could be used to detect aspects of the new program requiring change and improvement, but they also served to tighten up the training program generally through emphasis on adherence to presecribed procedures and through a focussing of attention on the day-by-day operation of the program. The Pueblo Project, to be reported later in this chapter, illustrates this precedure.

A second technique involved the questioning of students and instructors on various aspects of the course of instruction. It was found that such investigations often directed attention to

some area of inefficient operation, and thus made possible corrective action. The evaluation of an 8-week training curriculum, to be reported later, illustrates this technique.

A third technique involved research on some specific unit of work, rather than on the course of training as a whole. It was felt that research on particular problems should run concurrently with research on overall programs, as being the most plausible approach to improving training. In chapter 9 are summarized numerous studies of this nature.

A fourth technique involved the subjective analysis of a training program by psychologists using as a guide a series of principles characteristic of good training. Such a list, a summary of which is included in Appendix D, was used in the evaluation of an experimental eight-week curriculum, to be reported later in this chapter.

Techniques used in the evaluation of gunnery as a whole.—Establishing the validity of the assumptions upon which gunnery training was based was usually effected by studies of gunnery in combat theaters. These studies served to define the specific objectives of training, as had been outlined in chapter 5. They served also to check on the overall effectiveness of training programs by measuring the proficiency of gunners who had completed all of their training and were presumably ready for combat. Three such studies are summarized in the next section of this chapter, followed by a series of brief accounts of research projects directed toward the evaluation of specific training programs, and the discovery of ways in which training could be improved.

THE OVERSEAS PROJECTS—STUDIES OF GUNNERY IN THREE THEATERS OF OPERATION

Background Information

As a result of discussions at the Tampa Conference in April 1944 (see chapter 1), psychologists were sent to three theaters of operation for the purpose of checking on the proficiency of gunners in combat air forces and for the purpose of obtaining information which would be of value in the planning of gunnery selection and training programs. Three such missions were undertaken.[1]

The Problem

The methodologies and the specific objectives of the three missions varied in minor detail, yet all three studies involved observa-

[1] The study in the 7th Air Force was made by Capt. Mason Haire, in the 5th and 13th Air Force by Capt. Alfred C. Jensen, and in the China-Burma-India Theater by Capt. Wilbur S. Gregory.

tions according to a pre-arranged plan. In general, the objectives of the three studies may be defined as follows:

(a) To secure data of use in evaluating and revising the flexible gunnery training program in the States.

(b) To secure data on the level of proficiency of gunners in the theater concerned.

(c) To secure evidence regarding the validity of the content of the basic gunnery school courses and training standards.

(d) To secure recommendations regarding minimum aptitude standards for the selection of gunners and of gunnery officers.

(e) To secure data on the relation of personality variables to gunnery proficiency in combat.

Such information as would be obtained in achieving these objectives would provide materials for the improving of selection and of training procedures in the States. The significance of the obtained results for selection are covered in other chapters. Here, emphasis will be placed on the implications of the studies for program planning.

The Procedure

Several procedures were established for these investigations, prior to their undertaking; however, conditions in the various theaters prevented the uniform application of all of the procedures originally agreed upon. The individual officers were in several instances confronted with the necessity of improvising means of achieving the general objectives as outlined above. The following procedures were used:

1. Gunnery officers were asked to indicate minimum aptitude standards requisite for gunners, using a 9-point scale for rating certain designated characteristics. This procedure was followed uniformly in all three studies. The results are reported in Chapters 5 and 13.

2. Where possible, gunners were given available measures of proficiency, such as phase checks, Jam-Handy Trainer, and locally-constructed achievement tests.

3. Gunnery officers and gunners were interviewed to obtain information on the strengths and weaknesses of the gunnery training program.

4. A detailed check list covering elements in the then-current basic gunnery curriculums was submitted to gunnery officers to obtain an indication of the relative importance of each of the items listed. This was uniformly done in all three studies.

5. General procedures used to achieve the remainder of the objectives outlined above were to interview gunners, officers and

gunners, to observe gunners at work, and carefully to record judgments based upon information so obtained.

The Results

1. *Proficiency of gunners in combat theaters.*—The evidence relative to the proficiency of gunners after they had arrived in a theater of operations, presumably ready for combat, was not reassuring as to the adequacy of the gunnery training program in the States. These results are summarized below, for weapons, turrets, sighting, and general knowledge of basic principles in gunnery. Proficiency in the first three of these areas were measured by phase checks and the Jam-Handy Trainer, which provided an indication of the gunners' ability to perform their duties. Knowledge of gunnery was measured by achievement tests in use in the theater designated.

In the 5th, 7th, and 13th Air Forces, the standardized phase check on weapons was given to 26 gunners, selected at random from gunners available in operational squadrons. Of the 26 men tested, 22 failed to make a score which would be regarded as passing in the Training Command basic gunnery schools. On a 5-point scale, they received scale scores of 1. The remaining four men received a grade of 2, which was considered poor for basic gunnery school students and failing for gunners in the training air forces. None of these 26 gunners received a score as high as the average score for basic gunnery school students; only 4 of the men would have been considered qualified for graduation from basic gunnery training.

The picture is no better for proficiency in turrets. In table 11.1, the converted scores of 30 gunners in the 7th Air Force on the standardized phase check for their respective turrets are presented. Roughly, one-third of the men failed, one-third passed with a score of 2, and one-third reached the level expected of the average basic school graduate. Note that only two men passed the section on harmonization. Fourteen gunners in the 5th and 13th Air Forces were given the same turret phase checks. Of the 14 men, 8 failed, 2 received a score of poor, 3 were average, and 1

TABLE 11.1.—*Summary table of all turret phase checks (N=30, 7th Air Force, June-July 1944)*

Converted scores[1]	Total frequency	Par 1 (operation)	Part 2 (harmonization)	Part 3 (preflight)	Part 4 (loading)
5 (Excellent)				6	6
4 (Good)		6	1	12	7
3 (Average)	9	7	1	2	8
2 (Poor)	11				
1 (Fail)	10	17	28	10	9

[1] Converted scores are based on the performance of basic gunnery school students (see chapter 8).

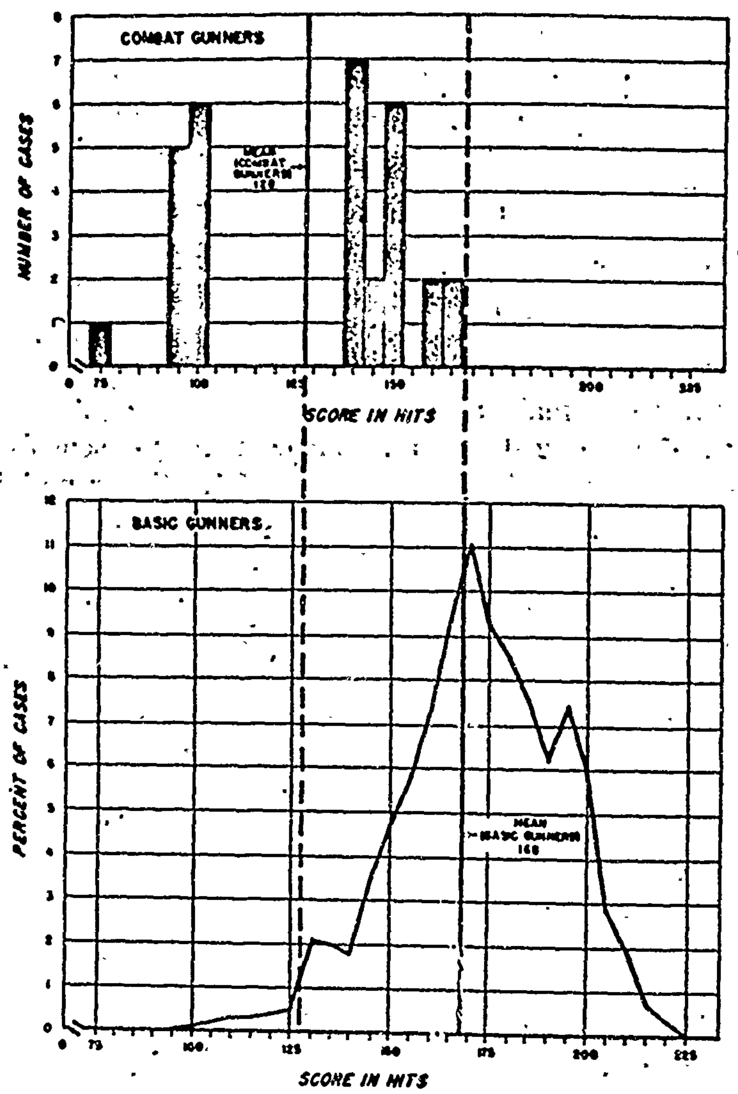

Fig. 111 — Proficiency of combat gunners: distribution of Jam-Handy (E-14) scores of combat gunners (bar chart) as compared with scores of basic gunnery students (frequency polygon) — 7th Air Force, June–July '44

achieved a score of good; the comparisons are again with basic gunnery school students. It is evident that these gunners were considerably less proficient than men graduating from basic training. Men in a combat theater might reasonably be expected to be at least as proficient as basic gunners.

The third area of proficiency measured by a performance test was sighting. A standard Jam-Handy test film was given to 31 gunners in the 7th Air Force. The men were scored in accordance with standard procedures in order to make their scores comparable with a norm group of basic gunnery school students. The results are presented in figure 11.1. It will be remembered from chapters 5 and 9 that the Jam-Handy Trainer, when properly used, provided a fairly adequate measure of a gunner's ability to apply proper deflections when using a ring sight. Of the 31 combat gunners studied, not one reached the level of performance of the average of the norm group of basic gunners. The scores reported show a definite inferiority of combat gunners in this fundamental skill required of all gunners in the air force studied.

The proficiency of combat gunners on general knowledge of gunnery was less adequately measured than was performance proficiency, for locally constructed achievement tests had to be used. However, the results are reported in such a fashion that some indication of the weaknesses of the gunners studied was obtained. Of a total group of 43 men tested, the number and percent missing questions on certain basic items of gunnery information are given in table 11.2. The test items included in the table were chosen from reported scores on 60 similar items to illustrate types of deficiencies found. When these results are considered in relation to similar findings on performance tests, it seems fairly clear that

TABLE 11.2.—*Proficiency of combat gunners in knowledge of gunnery: Number and percent of gunners giving incorrect answers to certain questions on standard examination for 7th Bombardment Group (N=43, 10th Air Force, July 1944)*

Test questions in abbreviated form	Giving incorrect answers	
	Number	Percent
1. What is correct distance from ring sight to eye on waist gun?	40	92
2. List three items to be checked in harmonizing the guns on the Sperry ball turret	40	92
3. List three items to be checked in leaving the Martin turret	33	76
4. List three items to be checked in harmonizing guns on Martin turret	33	76
5. What should you do first if reticle on N6A sight goes out?	32	74
6. List three items to be checked in postflight checking the gun	25	58
7. At what position in elevation should the guns be charged?	22	52
8. How is the oil buffer tube adjusted?	21	50
9. How can you get out of the Sperry ball turret if the power fails?	17	40
10. How is the headspace adjusted?	16	36
11. What are the symptoms of loose headspace?	11	26
12. How is the direction of [illegible]d changed?	8	18

the gunners studied were consistently weak in their knowledge of gunnery and in their ability to perform fundamental gunnery tasks.

2. *Reported deficiencies of gunners.*—Another technique used in these studies was to question responsible officers in squadrons and groups concerning the proficiency of the gunners assigned to them. Gunnery officers, armament officers, operations officers, and intelligence officers usually had an opportunity to become familiar with the repeated deficiencies of gunners, either in the care and use of their equipment or in their functioning as members of a fighting team. The opinions of such experienced men were not to be considered lightly. Officers intimately familiar with gunnery in the China-Burma-India Theater indicated the deficiencies that are summarized in table 11.3, which is a condensation of a longer table reported in the original study. Such material proved to be of value in guiding the development of curriculums in the basic gunnery schools and in the training air forces.

3. *Evaluation of gunnery courses.*—Gunnery school curriculums were given more explicit evaluation by a technique which required that officers familiar with combat gunnery assign comparative ratings to courses contained in curriculums in effect in gunnery schools at the time the study was made. The results of one such inquiry are summarized in table 11.4. Though there was a tendency among the officers questioned to give fairly high absolute ratings to all items (which suggests the now familiar

TABEL 11.3.—*Deficiencies of combat gunners: Frequency of reports of specific deficiencies of gunners, by squadron (N=13 squadrons, China-Burma-India theater, July 1944)*

Deficiencies reported	Number of Squadrons Reporting[1]
1. Turret manipulation and operation poor	13
2. Inability to operate all turrets on ship	13
3. Lack of knowledge of correct aiming point (position firing)	13
4. Failure to clean gun properly	10
5. Inadequate knowledge of first aid	10
6. Inability to correct malfunction of gun	9
7. Incorrect aircraft identification	9
8. Not proficient in care and use of oxygen equipment	9
9. Incomplete and inadequate preflight and postflight checks	9
10. Adjusting headspace poor	8
11. Not oriented to "zone of search" and "zone of fire" system	8
12. Burst control poor	8
13. Not proficient in care and use of interphone equipment	7
14. Hitting other AAF bombers in same formation	6
15. Inability to compensate for evasive action of own bomber	5
16. Not proficient in ditching procedures	4
17. Improper use and lack of skill in using Sperry Sight	3
18. Not proficient in filling oil buffer tube	2
19. Not proficient in care and use of armored suits	2
20. Not proficient in checking in procedure	2

[1] A deficiency is reported for a squadron if one of more of gunnery, armament, intelligence, and operations officers interviewed indicated a particular deficiency.

difficulty imposed by the lack of a definitive criterion for making such decisions), the relative ratings of the courses were felt to be significant. It is interesting to note that several of the most firmly entrenched courses in gunnery curriculums, such as skeet shooting and air-to-air firing, received little approbation from officers concerned with the ability of their gunners to hit attacking fighters.

Conclusions

Such studies as those reported above have little permanent value except possibly for suggesting techniques that might be useful in similar circumstances. Their value to gunnery lay in their immediate effect upon gunnery training programs at the time. Thus, care was taken to translate these fairly specific findings into conclusions and recommendations that could be used by officers responsible for the training of gunners. The concluding paragraphs from the 7th Air Force study throw light on some of the causes for the lack of proficiency of gunners, and indicate, as well, what courses of action might be taken to remedy the deficiencies. For these reasons, and because they convey the sense of immediacy which stamped much of the work in program planning during the war, the paragraphs are quoted verbatim below.[2]

> *Why is Proficiency Low?*—In an attempt to answer this question two hundred and sixty-six (266) gunners, who had just reported for duty in the Central Pacific Theater of Operations, were interviewed. The average training history of these men can be given in the following statistical picture: Ninety-three percent (93%) had training in Training Command schools. Slightly more than seven months elapsed after graduating from basic gunnery before the average gunner reported for overseas duty. During basic gunnery school he fired about 1,500 rounds in the air and 2,000 on the ground. In the training air forces he fired another 1,000 rounds in the air and about 150 on the ground. Two-thirds of the men had camera missions in their basic gunnery and three-quarters of them had camera missions in

TABLE 11.4.—*Evaluation of importance of courses taught in gunnery schools in the States by nine qualified officers in Tenth and Fourteenth Air Forces (July 1944)*

Course	Average[1] ratings	Course	Average[1] ratings
1. Caliber .50 machine gun	4.0	11. Waller trainer	3.7
2. Turret operation	4.0	12. Moving target machine gun firing	3.7
3. Aircraft recognition	4.0	13. Night vision	3.4
4. Range estimation	4.0	14. Turret maintenance	3.2
5. Position firing	3.9	15. Turret tower shotgun firing	2.8
6. Air-to-air camera gun firing	3.9	16. Skeet shooting	2.7
7. First aid	3.9	17. Moving base shotgun firing	2.6
8. Care of personal equipment	3.8	18. Air-to-air tow target firing	2.4
9. Tactics	3.8		
10. Jam-Handy trainer	3.7		

[1] Ratings were based on a 4-point scale, 4 being "essential" and 1 being "unnecessary."

[2] The original report was prepared by Capt. M[illegible] Haire.

Operational or Replacement Training Units. This is the average training history of a representative sample of combat gunners in the Central Pacific Theater. It seems to provide an adequate opportunity to learn to be a gunner. However, several real drawbacks seem to stand out.

a. Classification.—During basic gunnery training seventy percent (70%) of the men interviewed had no training in the aircraft to which they were assigned for duty, twenty-five percent (25%) of them had no training in the gun position which they were to fire in combat—only seven percent (7%) had all their training in this position. Even in the training air forces, when a man's overseas assignment is more nearly decided, thirty percent (30%) of the men were not trained in the gun position which they occupied in combat. These figures mean a hopeless unfamiliarity with equipment. In many instances this lack of familiarity gives a picture of complete inadequacy. A ball gunner reporting for combat duty in the theater of operations asked whether he would hit the plane if he fired forward. He had never heard of a fire interrupter. He had been trained in the waist gun and in the tail when a last minute sickness necessitated a new ball gunner. Another ball gunner, in combat, tried to take a 3-rad lead with his Sperry computing sight. These instances are duplicated many times. Men report for duty in B-24 units, trained only in the Sperry Upper turret; men report for duty with B-25 units trained in the Sperry Lower Ball turret. The assignment of untrained men to the operation of such highly complicated and delicate equipment seems wasteful and inefficient as well as dangerous to the ship and crew. These facts themselves carry a clear implication of the remedy which is necessary. It is suggested that the gunnery program would profit immensely from a strict classification system extending from basic gunnery school into combat duty which would make sure that men with specialized training are assigned to the positions where they belong and for which they were trained.

b. Forgetting.—It was pointed out before that when a man leaves basic gunnery school he has passed an exhaustive set of written examinations and performance checks on his gunnery proficiency. Seven months later, when he reports for combat duty, his proficiency has fallen to a startlingly low level. Why? The average training history of the men interviewed gives us a hint of the answer to this question. During the period of duty with the training air forces, the 266 men interviewed averaged 170 flying hours, but only fourteen hours of practice on turret operation. They seemed to be used to riding in the air, but two hours of turret operation a month seems wholly inadequate to maintain a motor skill at least as delicate as that demanded by a good golf game. The men were all asked how many times they had harmonized their guns during operational or replacement training. Sixty percent (60%) of them had *never* harmonized their guns during the seven months between graduation and overseas assignment. The average man harmonized 1.6 times; no one did it as many as ten times. In view of this fact, it is little wonder that the men in combat are almost completely unable to harmonize, and leave it to the armorer, who is able to do only an occasional job when he has the time. In many respects the duty between graduation from basic gunnery and combat seems to serve as an opportunity to forget, rather than to improve and consolidate, gunnery skills. Again the implication for a remedy is clear in the facts themselves. There are available tests and phase checks by which proficiency can be measured at any point in a man's training history. It is suggested that the quality of combat gunners can easily be assured and maintained by establishing a definite level of proficiency as a prerequisite to overseas assignment.

c. Lack of Air Experience.—When a group of gunnery officers and armament officers on duty with squadrons of the 7th Air Force were asked what was the most outstanding deficiency in gunners arriving for duty, their chief response was that the gunners were inexperienced in the operation of their equipment in the air. A turret gunner in basic gunnery school spends an average of twelve hours in his turret in the air, and another fourteen hours in operational or replacement training. With a total of twenty-six (26) hours it does not seem surprising that many men still feel strange in operating their equipment in the air. When this twenty-six hours is spread over a period of almost nine months, for an average of less than three hours a month, it seems as if gunnery training is not exploiting all of the time available for training in the air.

d. Theater Specialized Training.—The training program in the basic gunnery schools has so far been aimed chiefly at the European Theater of

Operations. Men are trained in basic gunnery schools to cover the operating parts of the gun with a very thin film of oil. This system is successful for the high altitude missions over Europe, but is hardly appropriate for the medium altitude missions in the Central Pacific area, where, without a liberal coating of oil, the gun may rust during the course of a single mission. Similarly, training with winter flying gloves is useless for gunners who will ultimately be assigned to the Pacific Theater. If it is at all possible to determine in advance the theater to which a man will be assigned, it is recommended that he be trained specifically for the peculiarities and individual problems of that theater.

e. Crew Training.—By the time a crew reports for duty in the theater of operations the members behave like a crew and feel themselves to be a crew in a good many senses. However, as gunners they are not a trained crew. Throughout basic gunnery training, gunners have been trained as individuals independent of the men around them. Much of this attitude remains in the gunners who are ready for action. The bombardier, who usually serves as gunnery officer on a plane, seldom has any knowledge of, or interest in, his job, and the men never seem to look to him as the leader of their gunnery crew. Much is done in the training air forces in the way of crew training. It is recommended that this training be begun in the Training Command schools and emphasized more in the training air forces.

f. Knowledge of Gunnery Problems.—The Training Command gunnery schools have suffered in the past from a lack of specific knowledge of the problems of flexible gunnery in the theaters of operations. Information on the type of enemy attacks, the range of enemy attacks, the range of breakaway, typical malfunctions occurring, typical personnel failures, and the like, has never been received with any regularity in the Training Command gunnery schools. Even in the 7th Air Force this information is obtainable only with difficulty. There has been no person or organization in the Air Force whose responsibility it is to compile and keep track of various factors and figures relating to problems of flexible gunnery. For the good of the Air Force in utilizing its gunners in combat, and for the good of the training air forces and the Training Command in preparing gunners for a specific combat job, it is recommended that an agency be established in the theater to do such a job of compilation and analysis. If this were possible, it would also be necessary to establish regular channels for the dissemination of information to the Training Command and the training air forces.

Evaluation

Such studies as these are open to many criticisms as to methodology. The number of cases was small and there was no assurance that the gunners studied were representative of all gunners in the theaters concerned. The studies were cross-sectional, and conclusions about forgetting were necessarily inferential. The recall method of testing was used, whereas a measure of the amount of training necessary to regain lost proficiency might have yielded a different picture. Nevertheless, the accumulated evidence was telling in its implications. Even assuming a most biased sampling, it would still have been necessary to seek causes for the presence in a combat theater of 22 gunners who could not pass a weapons check, or of 31 gunners no one of whom was as skilled in sighting techniques as the average gunnery school student. The findings of the three separate studies and the recommendations made were in close agreement. They resulted in several important developments in gunnery training in the States, including a permanent training-record form for all gunners, a plan for the continuation training of gunners in combat air forces,

and an extensive study of gunnery in the training air forces which will be reported subsequently in this chapter.

THE EIGHT-WEEK PROGRAM—AN EVALUATION OF GUNNERY TRAINING IN A TRAINING COMMAND BASIC SCHOOL[3]

Background Information

From the very outset, a close relationship existed between the psychological research program and the Training Command basic schools. As a consequence, the application of psychological principles and of the results of research to the problems of these schools produced manifold changes in basic training. Although these changes affected the program as a whole as well as specific parts of training, the desirability of designing an entire basic school program in accordance with all available evidence became increasingly apparent.

In November 1944, when it became likely that a reduced flow of gunners would permit the lengthening of the training period for basic gunnery students from 6 weeks to 8 weeks, the time seemed ripe for the development of an integrated program for basic gunners, utilizing to the fullest degree possible sound training principles and all relevant research findings. Since this program was developed for possible adoption as a standard training procedure in all schools, it was apparent that it had to be workable in existing training installations.

The Problem

The problem was to develop a practical training program which would be suitable for immediate introduction on an experimental basis at Laredo, and which would be the best attainable plan for training at that time. The evaluation of the new program in terms of knowledge, skills, and attitudes of the gunners trained constituted an integral part of the plan for putting the program into operation.

Procedure

The first step was the actual designing of the new program in terms of the principles stated earlier in this chapter, giving due consideration to existing conditions in the various gunnery schools with regard to equipment and personnel. No changes introduced in the experimental program required additional training personnel or equipment.

A comparison of the revised program with the program then

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[3] This study was planned and carried out by Lt. William B. Schrader, Lt. Thomas P. Gallagher, and Sgt. Alexander N. Levine, under the supervision of Capt. Leo O. Garber.

in operation at Laredo and other gunnery schools reveals the following specific changes:

1. The typical training day was decreased from 10 hours to 8 hours (including physical training in both instances).
2. Additional time was allocated to phase checks, including a preliminary phase check at the end of the fourth week and a phase check review at the end of the seventh week.
3. Time spent on the shotgun ranges was sharply reduced, and the time saved given to additional realistic practice on care of equipment on the Moving Target Range, where the caliber .50 machine gun was not only fired but also preflighted and postflighted by the gunner who fired it.
4. A definite increase in the amount of time devoted to turret drill was provided, including a 4-hour review near the end of training.
5. The gunner fired a shotgun on his first day of training and a caliber .50 machine gun on his third day of training, instead of waiting until the third week before actual firing was begun.
6. An orientation flight was introduced at the end of the second week of training.
7. On the flight line, all preliminary training was completed before air training missions were begun.
8. Training on the use of interphone equipment was increased from 4 hours to 5 hours.

This summary includes the more conspicuous changes introduced. In addition, however, all lesson plans were carefully reviewed and, where necessary, revised as part of the development of the new program.

The Experimental Design

The basic purpose of the evaluation was to obtain as accurate a comparison as possible of the proficiency and attitudes of gunners trained under the old and new programs. In addition, an effort was made to evaluate the new curriculum systematically in terms of training principles, and to study the functioning of the program in operation in order to discover whether further adjustments were needed. The plan for the evaluation further included a follow up of gunners trained in the 6-week and 8-week programs into the combat crew training phase in order to determine whether differences in proficiency attained at the completion of basic gunnery training persisted during further training.

In view of the fact that the revision of the curriculum might be expected to affect all aspects of the training, all quantitative data on gunnery proficiency available in basic gunnery schools were collected, including final achievement test scores, grades in the three academic courses, phase check scores, scores on the ground ranges, the synthetic trainers, intercommunication, and gun camera exercises. In addition, approximately 100 students trained under each program were interviewed at the completion of training in an effort to determine their attitudes. The cooperation of instructors was enlisted in order to obtain daily ratings of students' interest and participation, and to obtain ratings of certain aspects of proficiency not fully measured by the

usual scores. The gunners in this portion of the evaluation included all enlisted gunners trained in classes 44–50 and 44–51, the last two classes in the 6-week program; and all enlisted gunners trained in classes 44–53 and 45–2, the first and third classes trained in the 8-week program.

The design of the combat crew training phase of the evaluation had to be adapted to the fact that it was impossible to secure the assignment of the two groups of gunners studied in the initial phase to the same training installation. A group of 108 gunners from the 6-week program was assigned to Tonopah Army Air Field; and a group of 89 gunners from the first four classes trained in the 8-week program was assigned to Charleston Army Air Base. Conditions of training and of testing were found to be too dissimilar in these two training installations to permit any comparison of results except on a pretest, using the gunnery school final comprehensive examination, administered to both groups. However, data were collected on 87 gunners trained under the 6-week program at Tyndall and Laredo in classes 44–48 through 44–52, who received combat crew training at Charleston concurrently with the 89 gunners who had received 8 weeks of training at Laredo. From these data, it was possible to obtain some estimate of the relative effectiveness of the 6- and 8-week programs in terms of retention of knowledge and skills.

The Results

The results of this evaluation will be presented under three headings. First, attention will be given to the proficiency and attitudes of gunners at the completion of basic gunnery training. Second, results of the evaluation of the curriculum in terms of training principles will be briefly summarized. Third, the evidence regarding retention will be considered.

Evaluation of the curriculum in terms of the achievement of gunnery students.—Students trained under the new 8-week program were compared with students trained under the old 6-week program on the basis of five indices of achievement:

1. *Comparison of 6-week and 8-week students on knowledge of gunnery.*—Examination of results shown in table 11.5 on the Gunnery Final Comprehensive Examination (form GFD), and on course grades reveals a consistent superiority, although not a large one, for the 8-week students. This result may be attributed to two factors—improved alertness during the classroom period of training, and improvements in the lesson plans of the courses. It will be noted that on the Final Comprehensive Examination, this gain did not appear in the results for Class 44–53, the first 8-week class, a situation which may have resulted from a certain

amount of confusion connected with the installation of the new program. Study of the specific scores shows that the gains are indicative of an over-all favorable trend in knowledge of weapons, turrets, and sighting, with a slightly greater advantage for weapons.

2. *Comparison of 6-week and 8-week students on proficiency in care of equipment.*—Careful study of the phase check scores, table 11.6, fails to reveal any noteworthy shifts in proficiency, in spite of the increased training provided in the 8-week course. For the 8-week group, a slight gain in Martin turret scores is accompanied by drops in Sperry and Consolidated turret scores. Care and Cleaning of the caliber .50 machine gun also shows a trend toward slightly lower scores. These shifts are small enough to be attributed to ordinary fluctuation in proficiency of successive classes. It is significant that in spite of definitely increased practice for 8-week students on the phase check itself,

TABLE 11.5.—*Knowledge of gunnery of 6-week and 8-week students: Average scores attained on gunnery final comprehensive examination (form GFD) and on course grades in basic gunnery (December 1944-January 1945)*[1]

Subject	Six-week		Eight-week		
	Class 44-50 mean	Class 44-51 mean	Class 44-53 mean	Class 45-2 mean	Class 45-3 mean
Gunnery final comprehensive: Total	85.10	88.54	85.25	93.13	90.65
Weapons	33.19	33.68	33.09	35.26	35.19
Sighting	15.96	17.54	[illegible]	18.97	18.16
Turrets:					
Martin	31.93	33.28	31.43	33.64	33.87
Emerson	30.10	31.86	28.50	32.47	29.25
Sperry	31.95	32.16	31.75	33.57	31.18
Consolidated	26.06	26.61	27.04	29.79	27.29
Miscellaneous	5.32	5.78	5.54	6.21	5.85
Course grades:					
Weapons	80.47	77.93	80.82	85.30	—
Turrets	82.44	84.32	85.06	87.81	—
Sighting	80.08	79.61	80.84	83.12	—

[1] All means except for turret subtest scores based on approximately 114 cases. Martin turret means based on approximately 42, and other turrets on approximately 24 cases.

as a result of introducing preliminary phase checks in the fourth week and review phase checks in the seventh week, and in spite of an increase in emphasis on preflighting and postflighting of equipment throughout training, evidence of increased proficiency was not found. These results indicated that phase check proficiency was not markedly improved merely by increasing the amount of time given to phase check review and practice.

3. *Comparison of 6-week and 8-week students on proficiency in use of equipment.*—Table 11.7 contains scores for both groups on use of equipment. With regard to synthetic trainer performance, a noticeable gain in Waller Trainer scores for 8-week students ac-

companies a drop in E–14 Trainer scores. These shifts in proficiency correspond to changes in the number of hours allotted to those two trainers as an adjustment to training facilities available at Laredo.

Interphone scores, both in "Speaking" and "Listening," show a definite upward shift for the 8-week students. They may be attributed to the addition of one hour to the course of training and to increased use of interphone in the practical phase of the program.

On the Moving Target Range (turret) there is a slight gain in proficiency for the 8-week students, a gain which probably reflects the greater time allotted to this range, permitting firing to be carried on with less rush and confusion. Results on the Moving

TABLE 11.6.—*Proficiency in care of equipment of 6-week and 8-week gunners: scores attained on phase checks at end of basic gunnery training (December 1944–January 1945)*[1]

Subjects	Six-week		Eight-week	
	Class 44–50 mean	Class 44–51 mean	Class 44–53 mean	Class 45–2 mean
Turrets:				
Martin	4.09	3.78	4.17	4.14
Emerson	4.48	3.23	3.40	3.88
Sperry	3.60	3.70	3.35	3.43
Consolidated	4.33	3.74	3.43	3.68
All turrets	3.82	3.67	3.68	3.86
Weapons:				
Care and cleaning	4.53	4.28	4.13	4.27
Stripping and assembly	2.56	2.50	2.67	2.83
Harmonization	4.96	4.83	4.60	4.78

[1] Means except for turret phase checks based on approximately 114 cases. Martin turret means based on approximately 42, and other turrets on approximately 24 cases.

Target Range (hand-held) and Burst Control Range could not be properly evaluated because during the period between the time when the 6-week group fired and the time when the 8-week group fired, improved mounts were installed on the hand-held machine guns. As a result, the marked increases in proficiency shown in the scores is probably attributable to the improved mount in use, so that the evidence from these scores is inconclusive at best. Scores on the shotgun ranges for class 44–53 (8-week) fell off, a result which may be attributed to confusion arising from program changes. Results on class 45–2 (8-week) support this interpretation since a satisfactory level of proficiency on these ranges was achieved.

For gun camera, the scores attained by waist gunners and by Sperry and Martin men firing from their own turrets were the only data considered to be comparable. Only the first score achieved by a student was used, if more than one was available. The results are summarized in table 11.8.

Scores on gun camera fired from the waist position show a slight drop in performance for the 8-week students. It is probable that this resulted from the fact that a different method of sighting (the sight-base method) was used rather than the method emphasized in the 8-week sighting course (the eye-base method). The fact that a shift to K-13 sights on the waist guns was about to be made may have caused some students to take the iron ring-and-post sight practice on this position less seriously in the later classes. Performance on the Martin turret appears to have remained substantially the same during the period when the 8-week and 6-week groups were firing. Scores on Sperry Ball film vary markedly from class to class, with a slight advantage for the 6-week group. Although the results on gun camera are not conclusive, they tend, on the whole, to favor the 6-week group.

TABLE 11.7.—*Proficiency in use of equipment of 6-week and 8-week students: Average scores on various ranges and trainers during basic gunnery training November 1944-January 1945)*[1]

	Six-week		Eight-week	
	Class 44–50 mean	Class 44–51 mean	Class 44–53 mean	Class 45–2 mean
Synthetic trainers:				
E-14	87.90	89.06	86.68	84.46
Waller	24.84	24.98	30.00	33.38
Ground ranges[2]				
Burst control	44.90	46.53	64.16	65.46
Moving target (hand-held)	11.61	11.68	19.24	18.22
Moving target (turret)	20.88	21.88	23.28	22.51
Moving base	52.84	54.22	47.01	53.05
High tower	58.88	58.08	37.97	56.35
Interphone[3]				
Speaking	73.48	71.24	79.67	81.90
Listening	74.50	73.27	79.45	81.27

[1] All means based on approximately 114 cases.
[2] In interpreting ground range scores it must be stressed that the K-7 mount was installed on the hand-held caliber .50 machine guns on the Burst Control and Moving Target Ranges. It should also be kept in mind that the scores of class 45-2 for ground ranges are based on the last half of the rounds fired while the averages for the other classes are based on all rounds fired.

4. *Comparison of 6-week and 8-week students on ratings given by instructors.*—In order to obtain information on aspects of proficiency not fully covered by objective scores, instructors were asked to rate each student on 11 specific abilities each time he fired on a ground range or participated in a training flight. In the case of Moving Target Range (turret) and the Air Gunnery Range, data on both groups of students were judged to be sufficiently complete to justify comparisons. On the Moving Target Range (turret), a number of differences were noted in the ratings of individual students by instructors. Eight-week students earned a definitely higher proportion of favorable ratings on the ability to postflight their guns properly, on the use of proper

safety precautions, and on the smoothness with which they entered the turret. Moreover, the percentages of instances in which the instructor was able to observe preflight ability of his students jumped from 40 to 100, and the percentage of reports evaluating postflight ability rose from 13 to 98. These ratings reflect changes which may be attributed to the increase in emphasis on preflight and postflight checks, and the increased amount of time allotted to the machine gun ranges. Reports on interphone use were made only for the 8-week group; 94 percent of the definite ratings were favorable. The fact that ratings on ability to manipulate the turret well came out at 67 and 69 percent for the two groups and that switching procedure came out at 77 and 80 percent suggests that the ratings were conscientiously made, on the whole. The drop in favorable ratings on the Burst Control Range from 77 to 61 percent may be connected with the fact that certain adjustments were being made to deal with the new gun mounts on the Burst Control Range, which may have resulted in slightly less effective instruction on this range for Class 44–53 (8-week).

TABLE 11.8.—*Proficiency in use of equipment of 6-week and 8-week students: Scores on gun camera exercises during basis gunnery training (December 1944–January 1945)*[1]

Position	Six-week				Eight-week			
	Class 44–50		Class 44–51		Class 44–53		Class 45–2	
	N	Mean	N	Mean	N	Mean	N	Mean
Waist	36	2.53	31	2.71	49	2.51		
Martin upper turret	10	3.20	14	3.00	9	3.00	18	3.17
Sperry ball turret	21	3.00	16	4.12	22	3.73	14	2.71

[1] Gun camera scores were based on the December 1944 revised tables for the waist and Martin turret positions, and on the July 1944 system of scoring the Sperry ball. Insufficient data were available for Consolidated or Emerson specialists to justify presenting figures. Class 45–2 did not fire gun camera from the waist gun position.

Student ratings in air gunnery were also superior, on the whole, for the 8-week group, particularly on preflight and postflight checks of equipment and on ability to deal with malfunctions. A gain of 8 percent on favorable ratings on interphone use appeared, and, interestingly enough, the 8-week students were rated slightly better on Burst Control than the 6-week students. This result is not necessarily inconsistent with the Moving Target Range results since the 8-week students may have profited more from their training on the Moving Target Range than the 6-week group. The 6-week students scored a higher percentage of favorable ratings on use of oxygen equipment than the 8-week students, but those percentages are based on only a small number of

reports, since the great bulk of the reports indicated that there had been no opportunity to observe this ability. Only 9 percent of the 6-week reports and only 23 percent of the 8-week reports gave a "Yes" or "No" rating on ability to use oxygen equipment.

5. *Comparison of 6-week and 8-week students with respect to attitudes toward gunnery and gunnery training.*—In the course of their interview just before graduation from basic school, students were asked which of the two programs they would prefer. Among the 6-week students, 74 percent would have preferred the 8-week course; while among the 8-week students, 88 percent preferred it to the 6-week program. It was clear that the 8-week program, with its increased free time and shortened work day, appealed to gunnery students. (Most of the men who preferred the shorter course did so because they wanted to get their basic training over with in 6 weeks). Confirming this result, only 32 percent of the 6-week students reported that they had adequate time for sleep and recreation during their training, while 90 percent of the 8-week students were satisfied as far as free time was concerned. The extent to which students used the added time for study showed an advantage, but a smaller one, for the longer course: 38 percent of the 8-week group reported study as a spare time activity as compared with 27 percent in the shorter course. Finally, with respect to the interviewer's judgment of the student's attitude toward his gunnery training, a small advantage for the 8-week program was noted.

Attitude toward being a gunner at the beginning of training was quite similar in the two groups: 69 percent of the 6-week and 67 percent of the 8-week students recalled that they had entered training with a definite desire to be gunners; and only 12 percent in the 6-week and 16 percent in the 8-week group recalled a definite dislike for their assignment. At the completion of training, 85 percent of the 6-week and 90 percent of the 8-week group reported a definite desire for gunnery; and only 3 percent in each group stated a clear dislike for it. This reveals another small advantage for the longer course, but one which is of importance. The close similarity in attitudes at the beginning of the course may be considered to be evidence that the two groups were comparable with respect to motivation at the beginning of their training.

Evaluation of the curriculum in terms of training principles.—In an effort to evaluate the curriculum in terms of psychological principles, a check-list of questions based on familiar training concepts was developed. In answering the questions included in this check-list, information was derived not only from the various documents which constituted the formal statement of the new

program, but particularly from observing the program in operation, by careful evaluation of a large number of instructors' comments, and by analysis of suggestions made by students during the interview at the end of the course. The specific answers to these questions, since they concern very specifically a particular program at a given time, have already served their purpose, and are at best of historical interest. The answers with the questions, however, have been presented in appendix D, as illustrative of a fruitful approach to the evaluation of a curriculum in operation.

This part of the evaluation may be briefly summarized by stating that the experimental 8-week curriculum for the training of basic gunners was judged to be sound, although many spots of weakness were located, particularly with reference to the neglect of superior students and to the confusion associated with the ubiquitous changes in equipment and methods within the gunnery program. It is suggested that readers interested in the problem of surveying a training program refer to the indicated appendix for materials believed to be useful in many training situations.

Evaluation of the 8-week program in terms of retention of proficiency.—In interpreting the results in this phase of the study it is important to keep in mind the specific groups of gunners on which the data were obtained. These are:

a. Eight-week group. These 87 gunners received 8 weeks of gunnery training at Laredo in class 44–53, 45–1, 45–2, or 45–3. They began combat crew training at Charleston Army Air Base as members of the same class.
b. Six-week group (Tonopah). These 108 gunners received 6 weeks of gunnery training at Laredo in class 44–50 or 44–51, and had their combat crew training at Tonopah Army Air Field.
c. Six-week group (Charleston). These 89 gunners received 6 weeks of gunnery training at Tyndall or Laredo in classes 44–48 through 44–52, and entered combat training at Charleston at the same time as the 8-week group.

These groups were drawn from the original population in accordance with assignment procedures which were essentially independent of gunnery proficiency, so that it is believed that they are representative of the larger group from which they were chosen in so far as proficiency is concerned.

The average lapse of time between the end of basic gunnery training and the start of combat crew training for each of these groups was as follows: 8-week group, 9 weeks; 6-week (Tonopah), 7 weeks; 6-week (Charleston), 12 weeks. The 6-week (Charleston) group had somewhat more and the 6-week (Tonopah) somewhat less opportunity to forget what they had learned than the 8-week group. However, forgetting generally occurs most rapidly during the period immediately following learning, and even the shortest average lapse of time was seven weeks.

Examination of comparative scores for the three groups on various measures of proficiency obtained shortly after the groups arrived for combat crew training reveals that there were no considerable or consistent differences between students taking the 8-week and the 6-week basic course. In table 11.9 total and part scores for the three groups on the gunnery school final examination are presented. The differences which appear are not remarkable. Although scores on Form GFF (the newer form of the comprehensive examination) yield a slight advantage for the 8-week group over the two comparison groups, this superiority is not of very great magnitude, nor is it borne out by results on the older form of the test (Form GFD).

No important or consistent difference appears between the 8-week group and the 6-week (Charleston) group on measures of proficiency in care of equipment or in use of equipment.[4]

The relative proficiency of the two groups tested at Charleston is indicated in table 11.10, which summarizes scores made on various phase checks administered by the same instructors who were especially trained for the job. Again, no considerable or consistent differences appear.

TABLE 11.9.—*Knowledge of gunnery of 6-week and 8-week students: Average scores attained on gunnery final comprehensive (forms GFD and GFF) upon entering combat crew training (February-April 1945)*

	Six-week				Eight-week	
	Tonopah		Charleston			
	N	Mean	N	Mean	N	Mean
Gunnery final comprehensive (Form GFD):						
Total	103	85.3	83	87.7	85	84.4
Weapons	103	33.0	83	33.7	85	33.2
Sighting	103	17.1	83	18.4	85	17.5
Turrets:						
Martin	56	30.1	35	30.2	18	30.9
Emerson	1	23.0	26	28.0	16	27.7
Sperry Ball	15	31.1	8	33.4	20	32.7
Tail	31	27.0	14	29.4	31	26.3
Miscellaneous	103	5.8	83	6.2	85	6.8
Gunnery final comprehensive (Form GFF):						
Total	108	85.5	89	87.7	87	91.1
Weapons	108	30.4	89	30.3	87	31.2
Sighting	108	16.5	89	16.9	87	16.7
Turrets:						
Martin	58	20.5	43	18.9	22	20.2
Emerson	4	17.3	25	17.8	17	17.6
Sperry ball	16	18.1	8	22.6	18	21.8
Tail	31	18.4	13	21.2	30	24.1
Crewmanship	108	19.2	89	21.4	87	21.6

[4] For these measures, the data obtained on the 6-week (Tonopah) group are omitted in this summary report because in each instance uncontrollable differences in administration prevent a direct comparison of results. It may be said, however, that the available data for the 6-week (Tonopah) group gave no reason to believe that the 8-week students were superior in gunnery proficiency.

The same picture of no significant differences between the two groups was also found for the use of equipment. The results of performance on the E–14 Trainer are presented in Table 11.11. The total proficiency scores on this measure of sighting ability are identical.

And similar results were obtained for firing on the Poorman Range, as shown in the same table.

Conclusion

Briefly, it was concluded from this study that the experimental 8-week program as compared with the traditional 6-week program had a considerable advantage in student morale, a small advantage in learning, and no clear-cut advantage for retention of learning for training of the type studied. That the findings were largely negative does not lessen the value of the work done. On the basis of the study, it was possible to recommend with assurance that the gunnery training program need not be lengthened to in-

TABLE 11.10.—*Proficiency in care of e[illegible]nt of 6-week and 8-week students: Phase check scores attained at C[illegible]n Army Air Base (March-April 1945)*

Phase check	Six-week		Eight-week	
	N	Mean	N	Mean
Stripping and assembly	80	2.1	86	1.9
Care and cleaning (waist gunners only)	20	1.6	16	1.4
Part 5: Care and cleaning	60	2.1	67	2.8
Turrets:				
Sperry ball	7	1.9	20	1.4
Motor products	14	1.1	31	1.8
Martin	8	1.8	7	1.6
Harmonization (waist gunners only)	20	4.1	16	3.5

TABLE 11.11.—*Proficiency in use of equipment of 6-week and 8-week students at Charleston Army Air Base: Performance on the E–14 Trainer and on the Poorman Range (March-April 1945)*

Crew position	Equipment fired	Type of sight	Six-week		Eight-week	
			N	Mean	N	Mean
E-14 Trainer:[1]						
Nose	Emerson	Compensating	35	8.8	17	8.9
Lower	Sperry ball	Computing	13	8.8	20	8.6
Waist	K-7 mount	Compensating	21	8.8	18	8.7
Tail	Emerson	Compensating	14	8.8	31	8.8
Engineer	Martin	Compensating	8	8.8	7	8.6
Total			91	8.8	93	8.8
Poorman Range:[2]						
Nose	Emerson	Compensating	35	104	17	105
Lower	Martin	Optic	13	56	20	49
Waist	K-7 mount	Compensating	19	99	18	99
Tail	Martin	Optic	14	49	31	57

[1] Test film after 2 hours of training; each score is the average of 10 ratings, a perfect score being 10.

[2] Score is number of hits for 120 rounds fired.

crease the proficiency of gunenrs, but that the adding of 2 weeks with a revised curriculum might well be considered in the interest of the morale of the students. Thus, facts were supplied to higher headquarters on the basis of which a sound decision could be made with reference to the amount of time to be allotted to gunnery training. In an emergency, such as was experienced during the few years preceding this study, there is reason to be confident that the shorter training would be adequate. For less stressful times, the benefits that accrue from a longer training program would justify a more liberal expenditure of time for gunnery training.

THE PUEBLO PROJECT—AN EVALUATION OF GUNNERY TRAINING IN A TRAINING AIR FORCE

Background Information

On graduation from a basic gunnery school, gunners were assigned to one of four air forces within the continental limits of the United States for further training prior to being assigned to an overseas air force. The mission of these training air forces, as they were called, was to assemble the pilot, copilot, bombardier, navigator, and gunners into an aircrew, and to train them to work together as a combat team. Each of the crew members was assumed to be adequately trained in his individual job, and ready for additional training in the cooperative functions that must be mastered by all crew members if they are to be an effective fighting organization. Presumably, all that was required in the way of further individual training for gunners during this period was enough practice in basic skills to maintain their proficiency at the level reached upon graduation from gunnery school. Studies of the proficiency of gunners in the combat air forces (reported earlier in this chapter), however, revealed that they were deficient in many of the basic gunnery skills. This was due in part to the assignment of many gunners to gun positions other than the ones for which they had been trained, and to the fact that gunners were getting through Training Command schools inadequately trained. There was also reason to believe that gunners were forgetting some of the skills they learned in basic gunnery schools during their period of training in the training air forces.

The Problem

The most cursory investigation of training procedures in the training air forces at that time would indicate that gunners tended to be neglected during this important phase of training.

Emphasis on the training of pilots, bombardiers, and navigators was more or less assured, for their deficiencies might often be apparent in their performance. This was not the case for gunners, for whom there was no adequate routinely obtained measure of ability. In an effort to stimulate interest in gunnery in the training air forces and to provide at the same time a workable program for gunnery training, it was decided that a model continuation training program for gunners would be set up at Pueblo Army Air Base, and that this program would be compared for general effectiveness with the rather unimaginative course in gunnery then prevalent at most advanced training bases. Specifically defined, the problem was to initiate an improved program for continuation training of gunners and to evaluate the effectiveness of this program as compared with that of the existing program at the selected base.

The Procedure

The first step in the procedure was to work up a gunnery program for recommendation to the training air forces to take the place of the program in effect. To improve upon the current practice was not difficult, and a plan for training was soon devised. The particular principles given special stress in planning this program were:

1. *Learning the whole job in context.*—Basic gunnery schools at that time taught gunnery in a succession of courses not too intimately associated with one another. Courses on sighting, on the turret, on the machine gun, were presented to the gunner in neat packages, and little was done to help him put the contents of the packages together, it being assumed that this would be accomplished by the training forces. But the training air forces were not, in fact, doing this job at that time. To remedy this deficiency, the concept of two general courses, one on "care of equipment" and one on "use of equipment," was introduced. With such a plan, the gunner would have to preflight his equipment, harmonize his guns, load ammunition, operate his equipment, and postflight his equipment, as he would be expected to do in combat. These were called "operational exercises," and their main virtue lay in the fact that they required the gunner to conceive his job whole and to practice specific skills in their appropriate context.

2. *Motivation.*—Combat crew training was usually very dull for gunners, their most constructive activity during the three months often being to serve as ballast on pilot training flights, a practice picturesquely dubbed "sandbagging." Ground work on gunnery was dull and uninspired, with no goals to training being apparent. The new operational exercises considerably in-

creased motivation by their greater realism. The specific reward of being excused from routine drills for the specific achievement of perfect performance was even more effective in calling forth effort. It was the opinion of qualified observers that the requirement of a perfect score, rather than some lower standard, which made the job of the gunner more difficult, also made it more challenging, and dispelled some of the apathy that gunners had towards the wearisome repetition of skills once mastered.

3. *Spaced practice.*—The then customary practice of lumping all gunnery training for a given period into a block several hours long was discarded in favor of the system of breaking up practice into smaller units and spacing it over a longer period of time.

4. *Knowledge of results.*—Drawing again from established psychological theory, emphasis was placed on the gunner having continuous knowledge of progress and of deficiencies in his performance. Phase check answer sheets were used by review instructors to aid the gunner in ironing out specific weaknesses, and progress charts were used to maintain the interest of the gunner in improving his skills.

5. *Learning by doing.*—It was often easier for the instructor to talk about his subject than to guide the student in the intelligent practice of the gunner's job. The methods then current in gunnery training depended heavily on the value of the spoken and written word, and tended to neglect actual practice by the student. The new program insisted that students work at their jobs, under supervision of instructors, and that talking give way to doing.

The Experimental Design

An experiment was designed to determine whether the new program would be more effective than the traditional program in maintaining the proficiency of gunners during their crew-training period. The design of the experiment was quite simple. Approximately 400 gunners in training at Pueblo were divided into two groups, designated as Group A and Group B. Group A was trained under the new system of instruction and Group B was trained with the system of instruction that had been in operation at Pueblo for some time. The relative efficiency of the gunners in the two groups was measured by phase checks covering the caliber .50 machine gun and various turrets. Only one observation, taken at the end of the training period, was made on group B, the control group; whereas, five observations, taken at intervals throughout the 12-week training period, were obtained on group A, the experimental group.

The Results

In figure 11.2 and table 11.12, the gunners of group A, who

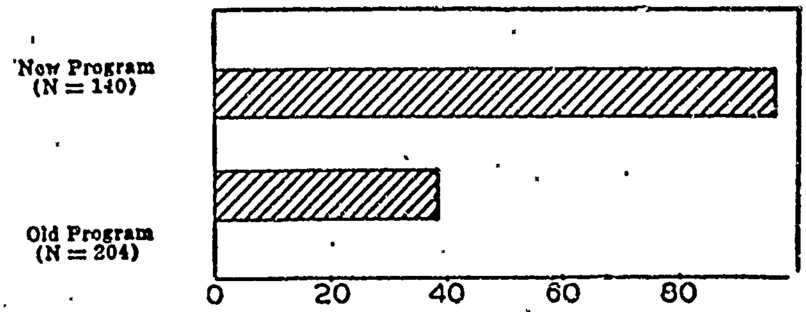

FIGURE 11.2.—*Percent of all gunners in old and new programs attaining perfect scores on turret phase checks upon completion of Combat Crew training (Pueblo Army Air Base, September 1944)*

were trained under the new program, and of group B, trained traditionally, are compared in terms of scores on the turret phase checks. These scores may be considered to be adequate measures of the gunner's ability to preflight his turret, to load ammunition, to turn on switches properly, and to make a postflight inspection—all essential aspects of the gunner's job. A quite striking difference in proficiency between the two groups is noted. Ninety-seven percent of the gunners in group A made perfect scores just prior to graduation, whereas only 38 percent of the gunners in group B achieved this level of proficiency by the time they were ready to be graduated. As shown in table 11.13, the percent of gunners who attained perfect scores on each of the four turret phase checks is markedly greater under the new program. In each of the four comparisons, the number of times that the difference between the two groups would arise by chance is less than 1 in 100.

TABLE 11.12.—*Final proficiency in turret phase check of gunners trained under old and new combat training programs: Number of men attaining various scores in each final turret phase check (September-November 1944)*

Score	Emerson		Motor products		Sperry		Martin		Total	
	Old	New	Old	New	Old	New	Old	New	Old	New
(5) [1]	16	45	16	24	16	21	30	46	78	136
5	12	0	9	0	19	0	7	0	47	0
4	22	2	24	0	9	1	6	0	61	3
3	0	0	3	0	0	0	1	0	4	0
2	0	0	0	0	0	0	0	0	0	0
1	2	0	2	0	6	1	4	0	14	1
Total	52	47	54	24	50	23	48	46	204	140
Mean score	4.42	4.96	4.30	5.00	4.34	4.78	4.50	5.00	4.39	4.95

[1] The "circle 5" (5) scores indicates that no errors were made on the phase check.

Expressed in terms of failure to achieve a passing score on the turret phase check (an unsatisfactory score being defined as a converted score of 1, which represents the level of achievement of approximately the lowest 4 percent of gunners graduating from basic schools), the difference continues to be clearly in favor of the experimental program, just prior to graduation of both groups. Of the gunners in group B, 8 percent failed to pass the check; of the gunners in group A, only 1 percent failed to pass.

Accurate record keeping permitted a profitable revision in the program of training for the experimental group when it was noted that 87 percent of the gunners in this group had achieved perfect scores on their turret phase checks by the time they had passed the mid-point of the training period. To prepare the gunners in the experimental group for possible assignment to a secondary turret position in combat, 77 percent of the gunners were given instruction in two or more secondary turrets. It is apparent that the experimental program not only accomplished prescribed training more adequately than did the traditional program, but it permitted a commendable extension of training which would prepare gunners better to meet emergencies likely to arise in a combat situation.

A notable outcome of the work at Pueblo was a general reorganization of gunnery training in all of the training air forces. Based on the results of the project and on experience gained in planning the experimental program, there was prepared a manual entitled "Standard Flexible Gunnery Program for B-17 and B-24 Combat Crew Training Stations, Instructor's Guide and Lesson Plans." All training air forces were directed by Headquarters, Army Air Forces to revise their gunnery program in accordance with procedures outlined in this manual.[5]

TABLE 11.13.—*Reliability of differences in percent of gunners attaining perfect scores on final turret phase check under old and new programs (September-November 1944)*

Turret	Old program (group B)		New program (group A)		Difference of percents	SE_{diff}	CR[1]
	N	Percent of scores perfect	N	Percent of scores perfect			
Emerson	52	30	47	96	0.66	0.07	9.4
Motor products	54	30	24	100	.70	.08	11.7
Sperry	50	32	23	92	.60	.09	6.7
Martin	48	63	46	100	.37	.07	5.3
Total	204	38	140	97	.59	.04	14.8

[1] All CR's reported in this column are sufficiently large that they would occur by chance in the absence of a true difference less than 1 time in 100.

[5] This project was planned by Maj. Roger W. Russell. The experimental work was performed by Lt. Frank J. Harris and Lt. James F. Lawrence. The manual was prepared by the above in cooperation with a committee of officers representing each of the four training air forces.

THE 8th AIR FORCE PROJECT—AN EVALUATION OF GUNNERY TRAINING IN A COMBAT AIR FORCE

Background Information

After 6 weeks of basic gunnery training and 12 weeks of crew training, with intervening periods of waiting for assignment, the gunner arrived at his combat air force as a member of a crew. By this time, the gunner should have reached his peak proficiency and be primed and ready to do his job with maximum effectiveness. But it is known from evidence presented earlier in this chapter that gunners often arrived in combat theaters less proficient than were recent graduates of basic gunnery schools. In the previous section of this chapter, the results of a study which led to a revision of the gunnery training program of the training air forces were presented. The same considerations concerning the maintaining of proficiency of gunners that prompted the training air forces study suggested that a similar study be undertaken in a combat air force. The desirability of such a study was enhanced by indications that important aspects of gunnery proficiency were being forgotten during the period when the gunner was flying on combat missions. The problem was worthy of investigation, and the suggestion that such a study be conducted in the 8th Air Force was accepted with enthusiasm by the gunnery officers in that command. Such a study was undertaken in January of 1945.[6]

The Problem

The problems of studying gunnery proficiency in an operational air force thus had two aspects: first, to obtain further information on the adequacy of gunners in certain basic skills when they arrived in the combat theater, and second, to determine experimentally what type of training program would be most effective in maintaining gunnery skill at the highest achievable level throughout the tour of duty in the theater. The 8th Air Force gunnery officers had already concluded that training must be continued throughout the gunner's combat tour. They were fully aware that the difficulties of conducting a training program in a combat theater required that the program achieve maximum return for the investment of time, personnel, and equipment made. They wanted concrete and practical recommendations that could be put into effect, and which would yield results proportionate to additional time and effort required.

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[6] This study was made by Maj. Roger W. Russell, Capt. John A. Valentine, and Lt. Frank J. Harris.

The Procedure

The gunners in four squadrons of one group of the 8th Air Force were studied. All of the gunners were given a series of tests, described below, at the beginning of the study. Following initial testing, each of the four squadrons was trained under a different training program. At the end of one month's training, all remaining gunners in each of the four groups were retested to determine progress made under each system of training.

The following measures of proficiency were used:

1. Standardized phase check on stripping and assembly of the caliber .50 machine gun;
2. For care and cleaning, a brief and relatively non-analytical revision of the postflight cleaning section of the standardized phase check, designed to meet the particular needs of the 8th Air Force;
3. Standardized phase checks on all turrets except Bell tail mount (omitting section on harmonization in all cases);
4. The Jam-Handy (E–14) Trainer, given as a measure of ability to use Position Firing rules;
5. Gun camera, given as a measure of proficiency in aiming and tracking;
6. Burst control, used as a measure of ability of the gunner to control a machine gun while firing.

Unfortunately, the last two of the above measures of proficiency yielded scores which, for a number of reasons beyond the control of the experimenters, were quite erratic and undependable. They were useful only in measuring the initial proficiency of the groups studied.

The four squadrons, designated by their assigned squadron numbers, were trained as indicated below:

Squadron 703 gunners flew three gun camera missions and, in addition, were required to practice until they could pass all phase checks with no errors, make a minimum qualifying score of 8.4 on the Jam-Handy (E–14) Trainer, and get a minimum of 18 hits out of 72 rounds fired in the 4-inch circle on the Burst Control Range. When these levels of proficiency had been met, the gunners in this squadron were excused from further practice until the final testing.

Squadron 709 gunners flew one gun camera mission and practiced the phase checks and the Jam-Handy (E–14) Trainer 3 hours a week throughout the training period.

Squadron 710 gunners received the traditional 8th Air Force gunnery training course, consisting of 1 hour a week practice on a turret trainer or on the Jam-Handy (E–14) Trainer, plus 3 hours per month of lectures.

Squadron 711 gunners received no formal training at all, beyond that inherent in the taking of the tests used.

The training period outlined above extended over a period of 1 month. During this period, the squadrons were flying combat missions. The number of gunners in each of the groups decreased over the 1 month period due to combat losses and to transfer of personnel who had completed their combat tours.

The Results

The proficiency of gunners arriving in the theater.—The initial testing of the gunners in the four squadrons yielded results which

showed that the gunners were more proficient than those tested in earlier studies in the 5th, 7th, 10th, 13th, and 15th Air Forces. Gunners in the four 8th Air Force squadrons were, however, below the minimum requirements prescribed for gunners under the standardized continuation training program of the training air forces, the evaluation of which was presented in the preceding section of this chapter.

The initial proficiency of the 8th Air Force gunners as measured by phase checks is indicated below. It should be remembered that no errors on these phase checks was the goal set for gunners graduating from the training air forces. That this goal could be achieved in practice was shown in the Pueblo study reported above.

1. Two percent of the gunners made perfect scores on stripping and assembly of the caliber .50 machine gun (N=606).
2. Twelve percent of the gunners made perfect scores on care and cleaning of the caliber .50 machine gun (N=408).
3. Seven percent of the bombardiers and navigators made perfect scores on the phase check for the turret to which they were assigned (N=151).
4. No engineer-gunners made a perfect score on the phase check for the turret to which they were assigned (N=151).
5. Five percent of the ball turret gunners made a perfect score on the phase check for the turret to which they were assigned (N=81).
6. Twenty-three percent of the tail gunners made perfect scores on the phase check for their position (N=78).
7. The average number of errors indicated that the failures were not by narrow margins, but were large enough to cause concern over the proficiency of gunners arriving in a combat theater, presumably adequately trained. Mean error score on various phase checks was as follows:

5.3 errors on stripping and assembly of caliber .50 machine gun.
2.1 errors on care and cleaning of the caliber .50 machine gun.
8.9 errors on the Bendix chin turret.
6.8 errors on the Sperry upper turret.
4.3 errors on the Sperry ball turret.
2.9 errors on the tail position.

Deficiency in ability to apply the rules of Position Firing was indicated by scores made on the Jam-Handy (E-14) Trainer at the time of initial testing. The average score for all gunners was 7.87 on a 10-point scale. This may be compared to the score of 9 which was the goal set for gunners before graduation from a training air force.

Gun camera scores were available for 213 of the gunners. Although these scores were obtained over the entire period of the

experiment, no gunner received enough practice on the gun camera to increase his skill in aiming and tracking. These scores can therefore best be thought of as further evidence of the proficiency of gunners in a combat theater. The average error of 137 gunners using non-computing sights was 44.6 mils. Comparable errors for gunners studied in one experiment conducted in the AAF Training Command was 23.9 mils. Errors of gunners using computing sights were: for tracking, 10.4 mils, and for framing, 8.4 mils. These errors may again be compared with errors in the same performance of gunners studied experimentally in the AAF Training Command, whose error scores were: for tracking, 8.4 mils, and for framing, 6.7 mils. Caution is needed in interpreting these differences because of difficulties in standardizing gun camera firing conditions.

The hypothesis that some aspects of gunnery proficiency actually decreased during a tour of combat duty received some support from data collected. Results of this aspect of the study are reported in table 11.14. Although the differences between gunners who had flown 25 or more missions and the gunners who had not completed 5 missions were not particularly large, all but one of the 7 comparisons favored the gunners with fewer missions. It is possible, of course, that these differences resulted from superior training in gunnery prior to assignment to the theater of the more recent arrivals; or that they resulted from greater effort in the testing situation by the gunners who were just beginning their missions. Since there is no reason to believe that the gunners in the two groups had received substantially different preliminary training and since the more experienced gunners appeared to cooperate adequately in the tests, the results may best be interpreted in terms of a tendency to loss of proficiency during the combat tour.

Experimental data obtained in a combat organization will always be less precise and thus less satisfactory than data obtained under more rigorous conditions of an experiment in a laboratory or under the comparatively stable conditions which obtain in a training organization in this country. Rigorous application of the usual requirements for acceptability of data would exclude virtually all of the data obtainable on performance in the combat theater. In particular, the relatively small number of phase check errors made even by the less proficient gunners complicates the interpretation of results. However, reasonably adequate data can be, and were, obtained. The data presented in this study are believed to provide evidence that gunners arrived in the 8th Air Force less well prepared to do their jobs than they might have been. They also support the view that

training must be continued throughout the combat tour of each gunner.

TABLE 11.14.—*Proficiency of 8th Air Force gunners just beginning and gunners about to complete a tour of 30 missions (April 1945)*

	First 5 missions		Last 5 missions		Diff [2]	CR [3]
	N	Mean score [1]	N	Mean score [1]		
Stripping and assembly	128	4.20	66	5.82	−1.62	3.00 ***
Care and cleaning	94	1.74	46	2.20	− .46	1.77 *
Chin turret	27	6.19	12	12.75	−6.56	3.13 ***
Upper turret	22	6.14	9	5.33	−.81	.58
Ball turret	18	3.83	8	4.50	− .67	.79
Tail turret	18	3.11	11	4.64	−1.53	.81
E-14 trainer	127	8.09	65	7.88	− .21	1.48

[1] Phase check error scores; E-14 raw scores based on a 10-point scale.

[2] The signs of the differences have been adjusted so that a minus sign indicates a decrease in proficiency, and a plus sign an increase in proficiency for gunners with the larger number of missions.

[3] Where either N was less than 30, Student's *t*-method was used in computing the CR. The significance of the CR's may be interpreted as follows: The probability that a value as large as reported would arise by chance is:
No asterisk: more than 5 times in 100.
*: between 1 and 5 times in 100.
**: less than 1 time in 100.
***: less than 1 time in 1000.

The optimum program for the training of gunners in a combat air force.—Following the initial testing of the gunners, the four training programs, described in the paragraph on procedure, were put into effect. Their relative efficiency was measured by performance on various phase checks and on the Jam-Handy (E-14) Trainer before and after training. Satisfactory comparisons could not be made using gun camera scores and burst control scores as these scores proved unreliable for this purpose.

The relative effectiveness of the training courses conducted in the four squadrons is compared in table 11.15 and graphically in figure 11.3. The results are presented in terms of the percentage of gunners achieving certain qualifying standards set for the 8th Air Force. These standards required a perfect score on indicated phase checks, and a score of 8.4 on the Jam-Handy (E-14) Trainer. The shaded areas indicate the percentage of gunners qualifying on the pretest and the unshaded areas indicate the gain in percentage of gunners qualifying on the posttest. The results are presented by squadrons.[7]

That the gunners in the four squadrons were roughly equivalent at the time of the initial testing is indicated by the pretest scores. For specific skills measured, only moderate variations

[7] Unfortunately, the report did not indicate the number of cases on which each percentage is based. By working backward from the critical ratios which were given, however, a value was computed to indicate the approximate size of each N. All N's reported in table 11.15 are believed to be within a range of ±3 of the correct value except that for stripping and assembly in Squadron 711.

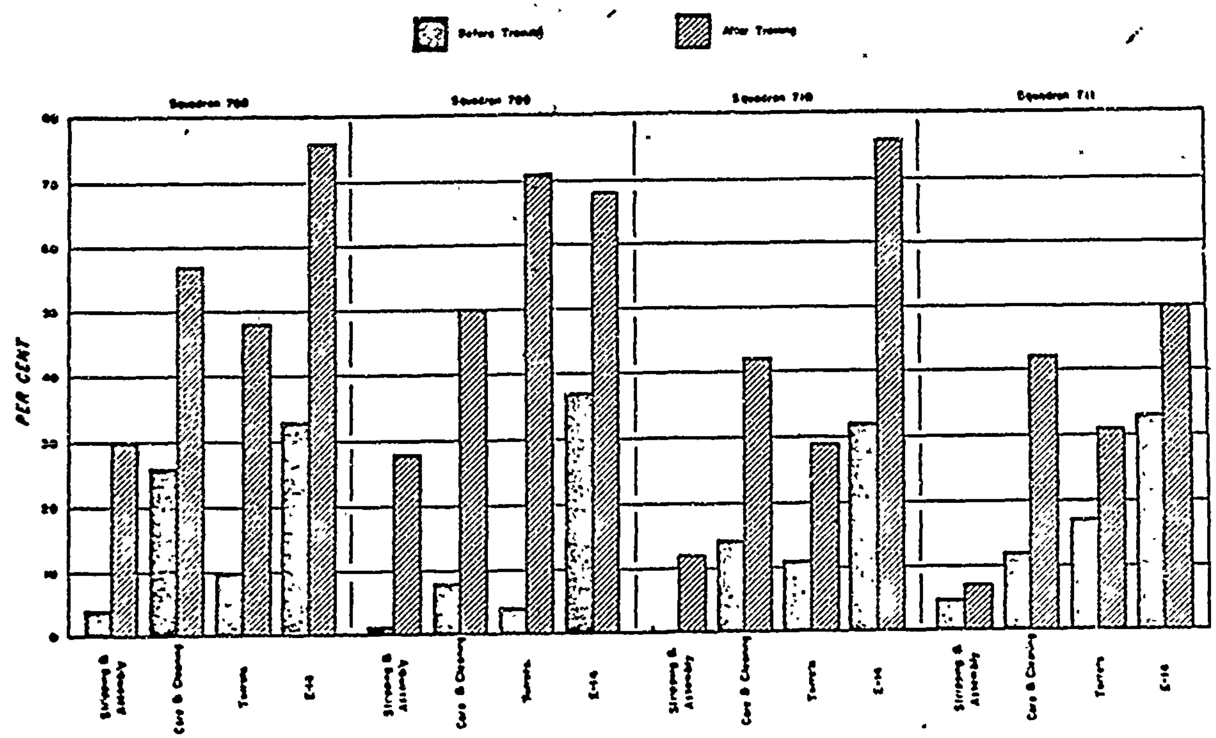

Fig. 11.3 – The proficiency of gunners of four 8th Air Force squadrons: percent of gunners achieving perfect scores on indicated phase checks, before and after training (Mar '45)

TABLE 11.15.—*Reliability of differences between percent of 8th Air Force gunners achieving minimum standards of proficiency at the beginning and end of the training program (March-April 1945)*[1]

	Squadron 708	Squadron 709	Squadron 710	Squadron 711
Stripping and assembly:				
Initial	4	1	0	5
Final	30	28	12	7
CR[2]	4.6 ***	4.6 ***	3.2 ***	0.6
N	79	63	77	118
Care and cleaning:				
Initial	26	8	14	12
Final	57	50	42	42
CR	3.3 ***	4.8 ***	3.7 ***	3.8 ***
N	51	43	65	58
Turrets:				
Initial	10	4	11	17
Final	48	71	29	31
CR	4.4 ***	6.9 ***	2.4 *	1.7 *
N	47	26	56	55
E-14 Trainer:				
Initial	33	37	32	38
Final	76	68	76	50
CR	5.8 ***	3.8 ***	5.9 ***	1.5
N	75	70	78	39

[1] All N's calculated from differences and CR's presented in original report.

[2] Interpretation of Critical Ratios: The number of asterisks indicate the likelihood that the CR could have arisen by chance in the absence of a true difference, as follows:

No asterisk: more than 5 times in 100.
*: 5 times in 100.
**: 1 time in 100
***: 1 time in 1000.

occurred, and these were of a size to be expected to arise by chance. When the amount of improvement shown during the period of training is evaluated, however, many of the gains in proficiency are relatively large. Indeed, all of the four comparisons for each of the two groups given systematic practice on the testing instruments show CR's greater than 3, the conventional standard for significance. The training program already developed in the 8th Air Force yielded similar results except for turret phase check proficiency. The squadron which received no formal training, however, showed gains which, except for the care and cleaning phase check, might easily have arisen out of chance variations. It is possible that the marked shift in proficiency on the care and cleaning phase check resulted from the practice effect of the initial testing of this group. This hypothesis was supported by the fact that, as noted earlier in this report, the care and cleaning phase check was brief and not highly analytical.

A most interesting observation grew out of the comparative performances of Squadron 708 and 709. It will be remembered that gunners in Squadron 708 were required to attain an initial high level of proficiency and then were excused from further practice until the terminal testing; whereas, gunners in Squadron 709 were required to practice systematically throughout the training period. Under the incentive of being excused from a tedious

practicing of skills believed to be mastered, 90 percent of the gunners in Squadron 708 reached the qualifying standard early in the training course. By the end of the practice period, however, they had lost their high degree of proficiency and had fallen to the level of the gunners of Squadron 709, who had been plodding along with less intense motivation. This suggested that a compromise between the two approaches might well be made, as was done in the final program recommended to the 8th Air Force.

The project resulted in concrete and practicable recommendations for improving gunnery training in the 8th Air Force. These recommendations are quoted below as illustrative of the immediately applicable outcome of such a project as has been described.

The proposed program is based upon certain minimum standards which every gunner must attain. These are:

Minimum Standards:

Caliber .50 machine gun phase check (stripping and assembly): no errors.
Caliber .50 machine gun phase check (care and cleaning): no errors.
Turret phase check: no errors.
Jam-Handy (E–14) Trainer test: average score of 8.5 or better.

As soon as a new gunner reports to the unit, he is given these tests. If he passes all of them, he is qualified for combat. If he fails any of them, he is not qualified and must practice until he can pass. The skills covered by these tests are so essential that a gunner cannot be considered as qualified unless he passes all of them.

Gunners who have qualified and are on operations are checked on these qualifying skills every two weeks. Those who pass all the tests are not required to practice in these basic subjects until they report for their next periodic test two weeks later. Any gunner failing one of these tests, however, is scheduled for additional practice in that subject until he qualifies.

To furnish additional motivation, it should be provided that a gunner who is not qualified is not eligible for promotion.

The tests in themselves provide 2 to 3 hours of practice a month, since the stripping and assembly check requires 30 minutes, the care and cleaning check takes 60 minutes, the turret checks take 60 minutes, and the Jam-Handy (E–14) Trainer test requires about 18 minutes.

There are three other types of practice which are important to the gunner, but for which it is impossible to establish dependable scoring methods and minimum levels because of uncontrollable variables which affect the gunner's performance. All that can be done in these fields, therefore, is to require that gunners, qualified or not, receive additional practice, as follows:

Subject	Hours per month
Burst control (fire a minimum of 72 rounds)	2
Gun camera (fly one mission per month and be shown the assessed film by an instructor)	2
Turret manipulation (turret gunners only)	2

If satisfactory methods of scoring these skills become available they should be added to the list of minimum standards. All standards and required practice periods should be changed, of course, to fit changes in the gunners' equipment, responsibilities, or training devices. Adoption of this Standard Practice Program should not prevent any unit from using any additional training procedures or devices it wishes.

Evaluation

The theoretical significance of such a study as has here been reported is inconsequential, for the data are not sufficiently precise, nor are the conditions under which they were obtained sufficiently well controlled or described to admit generalizations that would be widely applicable. But the study did have practical significance for the Air Force in which it was conducted, and this is sufficient justification for the amount of work which was done. The most obvious and immediate value of the study was its influence on the gunners participating in the squadrons. These gunners, being subjects in a project that was receiving enthusiastic support, were given the training which all gunners in a combat theater should have had during their operational tour. Finally, the influence of the project spread to other groups, which became concerned concurrently with improving their training programs.

BASIC GUNNERY REFRESHER TRAINING FOR COMBAT RETURNEES — AN EVALUATION OF A TRAINING PROGRAM DESIGNED FOR A SPECIAL GROUP[a]

Background Information

In recognition of the importance of the full and effective utilization of returned-from-combat gunners, psychologists in the AAF Personnel Distribution Command and in the training Air Forces, during the summer and fall of 1944, carried out studies which included material on the willingness of returnees to volunteer for a second tour of combat duty. These studies included 2,474 gunners passing through various redistribution stations, and 3,023 gunners already assigned to various airfields in the training air forces. Among the assigned gunners, 6 percent desired to return to combat immediately, and an additional 26 percent reported

[a] The refresher training program was developed and evaluated by Lt. Frank J. Harris and Sgt. Alexander N. Levine, under the general supervision of Capt. Robert A. Collins.

some desire to return or were indifferent toward returning. Among the gunners studied at the redistribution stations, 3 percent were "eager to return immediately," an additional 7 percent planned to volunteer in 6 months or so, and 23 percent more reported no objections to returning after a rest of 9 to 12 months in the United States.

In the study of the assigned gunners, it was also found that although 42 percent thought that they would need no additional training for a second tour, an appreciable portion of the remainder felt a definite need for more air-to-air firing, and for training in crewmanship, in turret operation, and in sights and sighting. It was also found that among the group of 1,650 assigned gunners, 53 percent had never received gun camera instruction, 36 percent had not had instruction on the Jam-Handy (E–14) Trainer, 29 percent had not had position firing instruction, and 20 percent had not studied preventive maintenance in gunnery school, according to their statements.

As a further development in the problem of utilization of returned-from-combat gunners, the need for a refresher training program adapted to their special experiences led to the development and evaluation of such a refresher course.

The Problem

The problem for this study was three-fold: first, to design a program which would efficiently bring the returnees up to proper standards of proficiency in basic gunnery and which would stress the newer developments in gunnery methods; second, to evaluate this program in terms of actual gunnery proficiency achieved through its use; and third, to modify the recommended program in terms of the results of the evaluation carried out.

The Procedure

In view of the extensive previous gunnery experience of returnees, special consideration was given to their characteristics in planning the new program. Among these characteristics for the group studied, the following features seemed especially relevant. Among the 253 returnees participating in the project, the average gunner had flown 39 missions, and fewer than 5 percent had flown less than 20 missions. However, the average gunner in this group had completed his basic gunnery training 21 months previously, 10 percent had never received basic gunnery school training, and only about 12 percent had completed basic gunnery within 1 year past. Preliminary phase checks and achievement tests administered to these gunners showed that less than 5 percent equalled or excelled the average gunnery graduate on gunnery knowledge,

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as measured by the Gunnery Final Examination; and less than 3 percent of the group could pass any phase check with a grade of 3 or higher.

Using the 8-week program described earlier in this chapter as a basis, the course for combat returnees was designed by reducing the amount of time devoted to various courses, by increasing the amount of emphasis given to newer developments in each course, and by considering throughout the fact that this was to be a refresher course for well-experienced gunners. After all adaptations in the program based on these considerations had been made, it was found that the training plan could be accomplished in a period of 3 weeks.

The experimental group consisted of two classes of combat returnees enrolled in the 3-week experimental course of training. At the start of the course, each class numbered 60, including 30 graduates of airplane mechanic schools, assigned to the Martin turret, and 30 graduates of armament schools, assigned to the Emerson turret. During the course of the experiment, one student was dropped from each class for administrative reasons. For these two groups, all available data on gunnery proficiency in terms of performance on the Gunnery Final Examination (GFE), on phase checks, and on ranges, trainers, and air-to-air firing, were obtained for comparison with the proficiency attained in these measures by basic gunners trained under the existing eight-week program.

Results

The basic results of this experiment are presented in tables 11.16 through 11.20. The overall picture presented by these data is one supporting the view that the 3-week program accomplished

TABLE 11.16.—*Knowledge of gunnery of combat returnees in 3-week course and of basic gunners in 8-week course: Average scores attained on gunnery final comprehensive examination (Form GFE) (January-March 1945)*

	Combat returnees—total		Basic gunners			
			Class 45-1		Class 45-6	
	N	Mean	N	Mean	N	Mean
GFE scores:						
Sighting	118	16.3	112	17.0	109	1[illegible].7
Weapons	118	34.8	112	35.1	109	32.3
Crewmanship	118	22.0	112	20.7	109	20.0
Turrets:						
Martin	59	23.6	43	23.0	44	23.7
Emerson	59	21.5	22	22.4	21	19.0
Total score	118	95.4	112	95.7	109	90.7

for these returned-from-combat gunners the same thing that the 8-week course was doing for gunnery students without previous experience.

More specifically, the returnees achieved a knowledge level which compared favorably with that of basic graduates. In weapons, crewmanship, and in total score on the final examination, they showed a slight superiority over the basic students. With regard to proficiency in the care of equipment, the returnees did not achieve as high a level on average scores on the care and cleaning and turret phase checks. No simple explanation of this difference appeared to be available. Item analysis results on the phase check errors indicated that the experimental group made its most frequent errors on detailed items of procedure. It appeared possible that greater stress on these points for the returnees would have brought them up to the level of basic gunnery graduates. It must be especially stressed that all of the returnees succeeded in passing all phase checks with a score of 3 or higher, as reported in table 11.19, and that the difference in proficiency between them and the basic gunnery graduates was not very great.

The performance of the experimental group in their basic gunnery courses and on the synthetic trainers compared favorably with basic gunnery graduates, as shown in table 11.17. The superiority of returnees on inter-communication, on weapons, and on the Jam-Handy (E–14) Trainer may be particularly noted.

TABLE 11.17.—*Proficiency in gunnery courses of combat returnees in 3-week course and of basic gunners in 8-week course: Average scores in courses, trainers, and ranges (February-March 1945)*

	Combat returnees, total mean	Basic gunners	
		Class 45–3 mean	Class 45–6 mean
Course Grades:			
Weapons	90.4	85.1	82.2
Turrets	86.0	87.2	85.7
Sighting	84.7	85.1	85.3
Trainers:			
E–14	90.1	86.4	86.9
Waller	22.3	33.0	27.7
Intercom. (speaking)	85.3	75.5	(2)
Intercom. (listening)	86.5	74.5	(2)
Ground Ranges:			
Moving base	(2)	53.6	54.6
High tower	59.3	51.3	58.0
Burst control	62.5	70.6	71.6
Moving target (hand-held)	10.1	19.3	19.1
Moving target (turret)	20.6	24.0	22.7
[1] N	116	105	110

[1] N actually varies slightly due to absentees, or small number of students dropped during later portions of course.
[2] Scores not available.

The somewhat poorer performance of the returnees on the Waller Trainer suggested that the returnees should be given the same amount of training as basic gunners received on it. On ground ranges, performance on the High Tower Range was comparable to that of basic gunners. However, on three caliber .50 machine gun ranges, Burst Control, Moving Target (handheld), and Moving Target (turret), the scores of the returnees were somewhat inferior to those of basic gunners. This suggested that additional time should be allotted to these trainers in a revised program, and posed a problem for further investigation.

The results on gun camera must be interpreted with caution because of the fact that scorable records could not be obtained for all members of the group and because the Emerson turret gunners in the experimental group, like their basic school counterparts, flew their gun camera training flights from the tail position, which is not equipped with an Emerson turret. However, such evidence as was available indicated that both Emerson and Martin gunners had attained at least as high a proficiency in this skill as did comparable basic gunnery graduates.

TABLE 11.18.—*Proficiency in care of equipment of combat returnees in 3-week course and of basic gunners in 8-week course: Average phase check scores (January-March 1945)*

Phase check	Combat returnees total		Basic gunners			
			Class 45-3		Class 45-6	
	N	Mean	N	Mean	N	Mean
Stripping and assembly	118	3.3	105	3.5	110	3.4
Care and cleaning	118	3.5	105	4.4	110	4.5
Harmonization	118	4.8	105	4.6	110	4.8
Martin turret	59	3.5	44	4.1	44	4.2
Emerson turret	59	3.4	18	4.1	22	3.9

TABLE 11.19.—*Proficiency in care of equipment of combat returnees after 8 days and after 3 weeks of refresher training: Percent passing phase checks with grade of three or higher (March 1945)*

Phase check	N	Number passing	
		8 days	3 weeks[1]
Stripping and assembly	118	77	102
Care and cleaning	118	92	111
Harmonization	118	103	116
Martin turret	58	58	58
Emerson turret	59	59	59

...dents who failed the 3-week phase check were given make-up check two days later, ...ed in each case.

TABLE 11.20.—*Proficiency in use of equipment of combat returnees in 3-week course and of basic gunners in 8-week course: Gun camera scores (March 1945)*

	Combat returnees total		Basic gunners			
			Class 45-10		Class 45-11	
	N	Mean	N	Mean	N	Mean
Martin turret	52	4.9	102	4.9	124	4.9
Tail turret	24	3.5	38	3.2	69	3.0

Conclusion

It is believed that this study had value not only in the fact that it provided an answer to a specific problem confronting gunnery training, but also because it illustrated the possibility of designing a curriculum for a group of trainees having important unique characteristics. It is true that the results of this study raised definite problems for further investigation, but the evidence found indicated that a reasonably close approximation to a satisfactory program had been developed.

CRITIQUE OF PROGRAM EVALUATION STUDIES

The evaluation of a complete training program in actual operation provided important information not otherwise available. Specifically, it had the following unique contributions to make: it permitted the evaluation of a new program in terms of an over-all picture of gunnery proficiency; it took full account of the interactions between the various phases of the training program; and it facilitated the uncovering of weaknesses in the new program of practical difficulties in the initiation of the newer procedures. In contrast to the typical laboratory experiment in which a specific procedure is studied in terms of specific criteria, the evaluation of a training program involved the comparison of the best program which could be designed on the basis of all available evidence with the program existing prior to the adoption of the new curriculum. Studies of this type were especially significant where there was an opportunity for initiating comprehensive changes in several phases of the program simultaneously.

The marked contributions possible through the evaluation of a complete program in operation must be weighed against the serious difficulties which beset such an attempt. Of these difficulties, the most serious was the impossibility of conducting the evaluation according to conventional psychological procedure for controlled experiments. Either the two groups to be compared

were trained at different times, thus confounding the results of changes introduced as integral parts of the new planned program with the results of changes occurring in the gunnery program for different reasons; or the groups to be compared were trained by different training organizations, thus confounding differences resulting from the new program with differences associated with the characteristics of the training organizations themselves. These difficulties must be recognized and stressed, because important changes in various aspects of gunnery training necessarily occurred during the course of evaluation studies, and because important deviations from the ideal of standardization were not completely eliminated at any time in the gunnery program. This limitation clearly prevented the evaluation studies from being scientifically rigorous. The fact that conditions of controlled experimentation could not be achieved made it essential that conscientious, persistent vigilance be exercised; first, to reduce uncontrolled variations to a minimum, and second, to record specifically such variations as did occur for consideration in arriving at the final conclusions.

A further problem encountered was the difficulty of obtaining adequate quantitative data on certain significant aspects of gunnery proficiency. In part, this resulted from the lack of suitable measures. More commonly, however, the failure to secure suitable data resulted from specific difficulties in the particular training situation which prevented the precise use of scores which would presumably have been valid under more favorable operating conditions.

In spite of the obstacles encountered, evaluation studies may be considered to have played a definite part in the improvement of gunnery not only because of the unique contributions such studies could make to the over-all picture of gunnery training, but because they served to provide definitely relevant information on problems which would otherwise have been dealt with by expert judgment, by tradition, or by heated argument.

SUMMARY AND EVALUATION

Psychologists in gunnery assisted in the over-all planning of training programs through three types of activities: the preparation of curriculums, lesson plans, manuals, and other instructional materials; the formulation of principles of program planning growing out of the application of psychological techniques to specific gunnery programs; and the systematic evaluation of training programs.

One of the most important of the systematic investigations of the effectiveness of gunnery training was the study of gunnery in

combat theaters. The results of three such studies, concerned with gunnery in the Pacific Theater during the summer of 1944, are presented, along with a brief evaluation of the contributions of such studies to the improvement of gunnery training.

An evaluation of two basic gunnery school curriculums is reported. This investigation compared the traditional 6-week training course with an experimental 8-week training course. The relative proficiency of students pursuing the two programs was assessed both at the end of their training period in basic gunnery and, later, during their training at a training air force station. In terms of gunnery proficiency at the end of basic training, the experimental program proved slightly superior to the traditional program; however, there was no evidence of superiority on measures of proficiency taken during a later period of training. In terms of the morale of the gunners pursuing the two courses, the experimental course was judged to be superior.

In an effort to increase the efficiency of interim training between basic gunnery school and combat, a model continuation training program was set up a training air force station and the proficiency of gunners under the new and old programs was compared. The experimental program was markedly superior to the traditional program. This work resulted in the revision and standardization of the course of gunnery training in all training air force stations.

A program not unlike that in the training air forces was extended to an operational air force to determine the most effective means of maintaining the proficiency of gunners during their combat tours. The results of the study are summarized and the recommended program for maintaining gunnery proficiency during combat is outlined.

During the final year of the war, the problem of planning refresher training for gunners returned from combat who had volunteered for a second tour of duty became important. To assist in this planning, an experiment was performed to determine the amount of training necessary to bring ex-combat gunners up to the level of proficiency of current basic gunnery graduates. It was determined that three weeks of refresher training was adequate to achieve this goal.

Such studies as have been reported in this chapter present an interesting problem in applied psychology. On the one hand, the methodology employed is open to many criticisms. The number of cases was frequently small; the criterion instruments were not highly sensitive; circumstances often forced changes in the experimental design during the course of an investigation; some extrapolation from available data was necessary to make de-

manded recommendations. On the other hand, the practical consequences of such undertakings in the over-all improvement of training should also be borne in mind. They forced a reconsideration of the objectives of a particular activity; they brought out various possible procedures for accomplishing the objectives; they provided a substantial amount of specific and often quantitative information to aid in decision-making; they made available a body of supplementary general information useful in program planning. Perhaps most important, they served as a stimulus and a guide for continued efforts to improve flexible gunery training.

CHAPTER TWELVE

The Selection and Training of Gunnery Instructors

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THE NATURE OF PROFICIENCY IN GUNNERY INSTRUCTION

The Task of the Gunnery Instructor

The task of the AAF Gunnery Instructor (Military Occupational Specialty 938) was officially defined as follows:

> Instructs military personnel in all phases of flexible gunnery.
>
> Conducts classes and maintains discipline among students; utilizes teaching aids such as charts, models, film strips and motion pictures; conducts range instruction with special reference to the observation of safety precautions; organizes students for training in air firing.
>
> Must meet the minimum qualifications required of an aerial gunner with the exception of qualification for flying duty which is desirable but not required; must maintain proficiency in the knowledge and skills required of an aerial gunner and have acquired a broader background of experience in flexible gunnery to be a competent instructor.
>
> Completion of flexible gunnery instructor course at an Army Air Forces school required.[1]

This description of the instructor's task was rather general. However, the requirement that gunnery instructors be graduates of any instructor training course implied that the standards applied by the school were also contained in the description presented above. It was, in fact, the Instructors School which usually determined whether or not a particular individual became a flexible gunnery instructor.

The organization of gunnery instruction.—Gunnery instruction was typically specialized instruction. That is, each instructor

[1] Army Regulations, No. 615-26.

taught a single aspect of gunnery, such as weapons or turrets or sighting. The instructors were not, however, trained to teach a particular specialty but were given a general course, specialization taking place after the instructor was assigned to a gunnery school, to a training air force station, or to an overseas gunnery training center for duty. This procedure was based upon the belief that although it was possible to divide the subject matter of gunery for purposes of presenting the material to the student, it was necessary for the instructor of each division to be aware of the problems of gunnery as a whole. Specialization of the instructors to the point where they would no longer be aware of gunnery problems which existed outside of their specialty would have tended to reduce the effectiveness of their instruction. A range instructor, for example, who did not know turrets, weapons, sighting, malfunctions, and so on, was not considered to be fully qualified to do his range job well.

The gunnery instructor was required to possess an intimate knowledge of subject matter within his specialty. In addition, he was faced with a relatively difficult teaching problem. In many phases of gunnery training, each instructor would see a particular group of students for only a few meetings. In these few meetings, the instructor had to impart a specific amount of knowledge to the student. This required that the instructor be especially effective, since the student had little time to accustom himself to unusual personal characteristics of the instructor. This was especially true since, for most students, gunnery was a new and difficult subject which had to be mastered quickly, against the pressure of time. This put great demands upon the instructor's resourcefulness, intelligence, and insight.

Types of gunnery instruction.—There were, in general, three types of gunnery instructors: range instructors, classroom instructors, and air firing instructors. The men in each of these groups faced different kinds of problems. The general characteristics of duty for each type of instructor are presented below.

(1) The range instructor.—The range instructor received the students after they had been subjected to a certain basic amount of classroom instruction. For the most part, however, range instruction represented for the students a new type of gunnery learning situation. The instructor was required to orient the students to the nature of the task at hand and to supervise the firing on the range. In addition, the instructor was required to be observant of student difficulties and to offer corrective instruction wherever necessary. In all types of range work, safety precautions had to be rigidly enforced by the instructor. This, in itself,

was a difficult task, considering the lack of range experience of the typical student. In order to be effective in his job, the range instructor had to be proficient in the fields of sighting, turret manipulation, weapons, malfunctions, turret maintenance, and range estimation. He had to be able to supplement classroom instruction in any of these areas.[3] The conditions under which the range instructors worked were often unfavorable. Oral instructions were given, in many cases, in competition with the noise of gunfire. The student was usually in a turret, where it was difficult for the instructor to observe his behavior, and where corrective instruction was difficult to administer.

(2) The classroom instructor.—The classroom instructor worked under more favorable conditions in many ways than did the range instructor. Gunnery classes were usually held in typical classrooms, equipped with blackboards, desk chairs for the students, and a speaker's stand for the instructor. Conditions of temperature, noise level, and so on, while not always ideal, were not as unfavorable as in the case of range instruction. The classroom instructor had to have a facile verbal grasp of his subject matter. He also had to be able to determine the difficulties of his students from their questions and by observation of their behavior. He had to be adept in using various training aids. Some 20 training films, numerous film strips, and several series of posters were prescribed for use in the gunnery-training program; skill was required to use these visual aids to maximum advantage. Most classroom instructors had to be familiar with phase checks, and some instructors had to be expert in the administration of phase checks as final tests of proficiency. Some instructors had to be familiar with the operation of the Waller Trainer, others with special techniques for scoring on the Jam-Handy (E-14) Trainer. Instructors in interphone had to be able to teach over the interphone and to administer tests of "talking" and "listening" in a classroom filled with ambient aircraft noise. All instructors had to be competent administrators of examinations, and they had to know simple statistical and clerical procedures for determining and reporting student grades. Like the range instructor, the classroom instructor had to be aware of problems in fields other than the area of his own specialization, yet this knowledge could be of a verbal, rather than a performance, type. In many cases, actual gunnery proficiency was not required of the classroom instructor in any field except that of his own specialty.

[3] The requirements for instructor proficiency differed on the various types of ranges. In ranges employing hand-held guns, for example, proficiency in turret manipulation and maintenance was not essential. On the other hand, on some ranges, such as the shotgun ranges, the instructor was expected to be an expert marksman.

(3) The air-firing instructor.—The most difficult of the instructing tasks was faced by the air-firing instructors. Some of the difficulties under which these men worked were pointed out in a report of job analysis for the gunnery student in the air-firing training situation.[3] This report stressed four main difficulties of instruction in air firing.

The first of these was that students who had never flown before exhibited a great deal of awkwardness in the flight situation. This was true of simple activities such as walking, carrying ammunition, and so on, as well as of more complicated activities such as turret manipulation. The reason for this awkwardness was stated in terms of the student's inability to react to the proper cues in operating his equipment and his tendency to react to cues which were irrelevant to the job to be done. Inexperienced students tended to be anxious and overly alert to motions of the plane, to the sound of gunfire, often reacting with random, inefficient activities.

Stress was placed upon the fact that communication with a student was extremely difficult. Talking, except for an occasional shouted word, was impossible, except between a few interphone-equipped positions. Much communication was accomplished by means of signs, lip movements, and gestures. The new student had difficulty in interpreting many conventional signs. This was brought out in the original report as follows:

> To the experienced gunner, a twist of the instructor's wrist may mean that he should lift the cover of his gun. To the naive gunner, this sign may be completely meaningless.

Another difficulty, and one which was extremely important for the air-firing instructor's task, concerned the lack of integration of skills on the part of the student. In gunnery training, the students learned many skills, typically in isolation from other skills. In the air-firing situation these skills had to be accomplished simultaneously. Furthermore, under the stress of the air-firing situation, many previously integrated skills appeared to break down. As stated in the original report, this difficulty was expressed as:

> Under such circumstances, the student may not only fail to integrate his previously-learned habits, but may actually appear to lose his skill at one or more of them. Thus a student who passes the malfunctions course with honors will persist in trying to hand-charge a second position stoppage. In one case it was noted that a student elevated his guns and charged them three times in succession although the ammunition had fallen from the feedway.

[3] This work was done by Lt. Arthur L. Irion.

The fourth difficulty mentioned in the report concerned the emotional behavior so often manifested by students in the air-firing situation. This was not a serious problem with students who had had extensive flying experience, but for many gunnery students the first few missions were frightening. This tended to reduce the student's efficiency and called for definite understanding and reassurance from the instructor. As one instructor put it:

He was nearly sick on the way back, so I took him to the waist with me and pointed out things to him through the window. Sometimes you have to put your arm around them and pat them on the back a little bit to let them know you think they're all right and that being scared is something that happens to everybody.

In addition to these student difficulties, the conditions of instruction were very poor. Often a single instructor accompanied a crew of 8 or 10 student gunners on a firing mission. In the cramped interior of the plane, the instructor could sometimes neither see his student nor talk to him over the interphone. Yet he was expected to solve the student's problems and to give corrective instruction wherever necessary.

The skills required of the air-firing instructor were more extensive than in the case of other instructors. He had to know virtually every phase of gunnery, including special skills such as gun camera techniques. He was required to be especially skilled in "calling" attacks for the students, telling them when to open fire, when to cease fire, and pointing out to them the characteristics of each of the various types of attack. In consideration of the hazards involved, the air-firing instructor had to emphasize safety precautions more than other instructors.

The mode of living of air-firing instructors presented unique problems. In many schools, these instructors were required to fly more hours per week than was consistent with the maintenance of personal efficiency. In one school, air-firing instructors were expected to fly ten or eleven 4-hour missions a week. Time off was limited to 1 afternoon a week. In addition to strenuous aerial duties, instructors were required to hold preflight briefings and postflight critiques. They were also responsible for the loading of the plane with guns and ammunition. These duties often kept the air-firing instructor on duty from 5 o'clock in the morning until 6 o'clock in the evening. Such conditions often led to a continuous state of fatigue, which was aggravated by the normal nervous strains experienced by those engaged in a hazardous occupation. Inevitably, the instructors were involved in frightening situations upon occasions. These conditions served to increase the difficulties under which the air-firing instructors worked.

Measuring Proficiency in Gunnery Instruction

It should be evident that the task of the gunnery instructor was often complicated and difficult. To select and train competent instructors, it was necessary to establish some measure of instructional proficiency. A determination of the influence of the instructor upon student performance would have been indicated had there existed an adequate criterion of gunnery proficiency.[4] Unfortunately, such an instrument was not available. Because of this lack, instructional proficiency could not be determined on the basis of student performance. Consequently, efforts were directed toward developing criterion measures in accordance with the assumption that instructional qualities and techniques which were considered to be of importance in the teaching of other subjects would also be important in the teaching of flexible gunnery. On the basis of careful rational analysis, four qualities were selected as being of prime importance for instructors. These were:

1. The intelligence of the instructor.
2. The amount of gunnery knowledge possessed by the instructor.
3. The degree of personal adjustment of the instructor.
4. The facility of the instructor in putting to use accepted principles of teaching.

It should be noted that intelligence and personal adjustment, which might have been thought of as predictors of teaching proficiency, were instead considered as integral parts of the criterion. Methods of assessing these characteristics are discussed in the following pages.

The measurement of instructor intelligence.—It was considered that the intelligence of gunnery instructors was measured adequately by the Army General Classification Test. A discussion of the level of intelligence required of gunnery instructors, and a discussion of selection procedures as these related to instructor intelligence are presented later in this chapter.

The measurement of gunnery knowledge.—The inclusion of gunnery knowledge in the criterion was believed to be justified by the fact that the instructor, in contrast to the gunner, needed an adequately verbalized understanding of gunnery. Measurement of the instructor's gunnery knowledge was accomplished by means of standardized objective examinations. These examinations were administered at two periods of the instructor's career: before he attended the Instructors School, and while he was in attendance at the school. In the former case the examination of gunnery knowledge served as a basis for the selection of properly

[4] A discussion of possible criteria of flexible gunnery proficiency is given in ch. 5.

qualified instructor material, whereas in the latter case the examination served as a basis of measuring achievement in the Instructors School and of eliminating unqualified men from instructor training.

As a basis for instructor selection, two examinations were used at various times: the Gunnery Final Examination (in any of several forms) and the Instructors Qualifying Examination. The latter examination was based upon the Gunnery Final Examination and was composed of the items which had proved to be the most discriminating while contained in the Gunnery Final Examination.[5] Reliability coefficients of scores obtained on the Instructors Qualifying Examination ranged between 0.80 and 0.90. The Gunnery Final Examination showed a similar range of reliabilities. The reliabilities of scores on form D ranged between 0.80 and 0.85, while reliabilities obtained from forms E and F ranged between 0.85 and 0.90.

Measurement of gunnery knowledge as a basis for elimination from instructor training was accomplished by means of the Instructors Comprehensive Final Examination. Reliabilities on this test, as determined in various classes, varied between 0.79 and 0.90.

In the measurement of the amount of gunnery knowledge possessed by the instructor it was assumed that, other things being equal, the more gunnery knowledge the instructor possessed, the greater his proficiency would be.[6]

The measurement of personal adjustment.—It was assumed that, other things being equal, those individuals who manifested the fewest neurotic symptoms would prove to be the most proficient instructors. In terms of neurotic impairment, in terms of the necessity for the instructor to react realistically and sensitively to the needs of his students, or in terms of the necessity for instructors to behave in an efficient manner in potentially dangerous situations, it appeared that this assumption might be fairly made. However, no demonstration of the most desirable personality structure for instructors was made.

Fortunately, a small but excellent standardization group existed, against which validation of measures of adjustment of instructors could be accomplished. This standardization group was made up of instructors at the Instructors School. These individuals, who had been carefully selected from among gunnery-school instructors and the graduates of the Instructors School, represented a

[5] The Gunnery Final Examination is described in ch. 7. The Instructors Qualifying Examination will be treated later in this chapter.

[6] For a discussion of how the scores obtained from these tests were used in the selection and elimination of instructors, see ch. 13.

highly effective and able group of instructors, both with respect to their ability and to their personal characteristics. An evaluation of the ability and adjustment of the group of instructors at the Instructors School is difficult to document. Information on the procedures used in the selection of these individuals is perhaps the most satisfactory way to indicate the caliber of these men. A potential instructor at the Instructors School had first to be selected to attend the school as a student. This meant that he had met high standards of intelligence and gunnery knowledge. As a student in the Instructors School, he would be considered for possible retention as an instructor only if he were sufficiently outstanding to obtain favorable recommendation from his instructors. If recommended, he would then be interviewed by an officer in charge of one of the instructional departments. Candidates endorsed by these officers would then be scheduled for an interview with an officer whose main function was to enforce high standards of instructor selection. If recommended by this officer, the student would become a candidate for selection as an instructor and would be called before an Instructor Selection Board. This board consisted of key officers from each of the instructional departments, the officer in charge of the instructors, and, often, a psychologist. The candidate would be examined carefully and thoughtfully by this board on the basis of a standardized examining procedure. This board was concerned more with the personal adequacy and adjustment of the individual than with his proficiency, since the student had already passed through several screenings intended to weed out the incompetent. Only those students who were endorsed by the Instructor Selection Board were retained on the staff of the Instructors School. Approximately 5 percent of Instructors School students in each class were selected for retention on the staff. The group of instructors, obtained under these procedures, was considered to be as fine a group of instructors as could be gathered together in a military situation. For these reasons, it was decided to make the personality characteristics of this group serve as a standard against which the adjustment of individuals in other groups could be compared.

The measurement of teaching proficiency.—In order to measure the instructor's facility in the application of commonly accepted principles of instruction, it was expedient to establish a situation in which the instructor's teaching behavior could be observed. The instructor who was already teaching in a gunnery school could be observed in his classroom, but a situation for measurement was most needed in the case of student instructors. It was, therefore, necessary to provide a practice teaching situation in

which the behavior of the student instructor could be observed directly. This not only afforded an opportunity to measure the student's proficiency, but it also afforded an opportunity for the student to teach under supervised conditions and a chance to gain experience which he could not otherwise have obtained.

For purposes of measuring the student's teaching proficiency, a rating scale was constructed in April 1943. Variables for the scale were based on the consensus of officers interested in the training of instructors and on civilian experiences of the psychologists who constructed the scale. Fourteen characteristics, deemed important to effective teaching, were included. Scale values varied from one to seven. Ratings were made on each of the 14 items, where applicable, by each person doing the rating. In addition to the identification of the characteristic of each item by name, the low, middle, and high points of the scale were defined for each item by descriptions of the instructor's behavior. Each of the items, together with the statements which defined the various scale values for it, is presented below:

1. *Appearance and bearing.*—
   - Low: Very poor appearance, poor bearing, untidy, careless of person.
   - Middle: Acceptable appearance, fair bearing, fairly neat and well groomed.
   - High: Very favorable appearance, good bearing, neat and well groomed.
2. *Voice.*—
   - Low: Has poor teaching voice; unpleasant, poorly modulated, weak.
   - Middle: Has fairly good teaching voice; moderately agreeable, well modulated, loud.
   - High: Has good teaching voice; pleasant, well modulated, sufficiently loud.
3. *Fluency.*—
   - Low: Poor articulation; presentation markedly jerky, monotonous.
   - Middle: Fair articulation; presentation sometimes jerky, monotonous.
   - High: Very good articulation; smooth flowing presentation.
4. *Poise.*—
   - Low: Lacks self-control and assurance; is nervous and ill at ease.
   - Middle: Shows some composure and presence of mind, but is not entirely at ease.
   - High: Shows self-control and assurance; is completely at ease.
5. *Logic.*—
   - Low: Presentation lacks coherence; reasoning poor and hazy.
   - Middle: Thinking slightly disorganized but reasoning generally sound.
   - High: Presentation coherent and reasoning sound.
6. *Ability to express self.*—
   - Low: Expresses himself very poorly; is sometimes obscure, unintelligible.
   - Middle: Expresses himself moderately well; at times is vague.
   - High: Expresses himself clearly and accurately.

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7. *Use of teaching aids.*—
   - Low: Fails to make effective use of teaching aids.
   - Middle: Occasionally uses teaching aids effectively.
   - High: Uses effectively charts, blackboards, illustrations, anecdotes.

8. *Originality.*—
   - Low: Procedure entirely routinized; teaches in mecnanical fashion.
   - Middle: Has some freshness; sometimes misses chance to escape routine teaching.
   - High: Teaches creatively; uses fresh ideas, humor, new and interesting methods.

9. *Ability to arouse interest of students.*—
   - Low: Students bored and indifferent to instructor or job.
   - Middle: Students show spurts of attentiveness, or are only casually interested.
   - High: Students alert, enthusiastic, attentive to instructor.

10. *Feeling between instructor and students.*—
    - Low: Feelings negative; antagonism, fear, resentment evident.
    - Middle: Attitudes neutral; neither friendliness nor antagonism seem to prevail.
    - High: Feeling of good will strongly prevails.

11. *Student participation in class.*—
    - Low: Students never participate.
    - Middle: Students occasionally participate.
    - High: Students frequently participate.

12. *Today's preparation.*—
    - Low: Completely unprepared, both as to content and means of presentation.
    - Middle: Mediocre preparation; work of class not well planned or organized.
    - High: Completely prepared; has planned and organized all work of class.

13. *Knowledge of subject.*—
    - Low: Serious lack of knowledge of subject; gives misinformation.
    - Middle: Generally appears well informed but seems to lack mastery of subject.
    - High: Demonstrates complete mastery of subject.

14. *General effectiveness as teacher.*—
    - Low: Poor teacher.
    - Middle: Fairly good teacher.
    - High: Very superior teacher.

Raters were first carefully indoctrinated on the use of the scale, following which a study of the reliability of the ratings was carried out.[7] Students of the Instructors School classes were rated by instructors from the school who had previously been indoctrinated in the use of the scale. All raters assigned ratings independently on the same teaching performances. Odd-even ratings

[7] This study was conducted by Lt. Thomas P. Gallagher, Master Sgt. Jack D. Adams, and Sgt. Ardie Lubin.

of these instructors were correlated, and it was found that corrected correlations ranged for 8 raters from 0.76 on "Ability to Express Self," to 0.94 on "General Effectiveness as Teacher." Table 12.1 presents these data. On the basis of these results, it was recommended that a board of five especially trained Instructors School graduates be used to rate all Instructors School students on teaching proficiency, as measured by the scale. This recommendation was carried out. Later, however, only two raters were used in the evaluation of students. In order to test the reliability of 2 raters, ratings on 155 students as rated by pairs of raters, were correlated with each other. The correlation coefficient as corrected by the Spearman-Brown formula was found to be 0.90 for "General Effectiveness as Teacher." Table 12.2 shows the intercorrelations of items on the rating scale. It should be noted that the ratings on the first 13 items correlate fairly highly with the "General Effectiveness" item. These correlations were considered to be sufficiently high to warrant the use of the rating on this item rather than the use of a combination of scores on the other items. It was felt necessary, however, to insist that the raters complete the first 13 items prior to making a rating on "General Effectiveness as Teacher."

With the passage of time, less attention was paid to the indoctrination of raters on the use of the rating scale. In order to test whether or not the reliability of the rating scale was being maintained under these conditions, several months after the studies reported above, pairs of raters were observed in operation, and their ratings on 104 students were collected. The correlation between raters for the "General Effectiveness" item was found to be 0.68.

This decrease in reliability indicated that the insistence upon

TABLE 12.1.—*Reliability of gunnery instructors rating scale: Odd-even reliability coefficients (Spearman-Brown) for eight raters (class 43-9, 43-10, Buckingham, July 1943)*

Item	Class 43-9 (N = 85)			Class 43-10 (N = 30)		
	r	M	SD	*r*	M	SD
Knowledge of subject	0.91	4.36	1.36	0.93	4.24	1.36
Today's preparation	.92	4.25	1.43	.90	4.32	1.43
Ability to arouse interest of students	.90	3.88	1.17	.89	3.84	1.19
Use of teaching aids	.90	3.79	1.30	.89	3.67	1.36
Originality	.87	3.73	1.21	.87	3.69	1.24
Ability to analyze students' problems	.88	4.13	1.18	.83	4.12	1.10
Feeling between instructor and students	.89	4.32	.85	.79	4.24	.89
Ability to express self	.76	4.26	1.02	.90	4.15	1.21
Logic	.86	4.35	1.09	.85	4.19	1.12
Fluency	.78	4.2[illegible]	1.06	.86	4.08	1.19
Voice	.77	4.15	1.12	.86	4.18	1.17
Poise	.82	4.46	.87	.81	4.15	1.01
Appearance and bearing	.79	4.35	.92	.80	4.56	.93
General effectiveness	.94	4.01	1.29	.94	3.93	1.27
Total	------	4.15	1.40	------	4.10	1.21

thorough training in the use of the scale and constant check of the work of the raters was extremely important in maintaining the reliability of the measurements obtained on the scale. It was felt that it was the emphasis upon the training of the raters which made the difference between the results obtained by means of this scale and the results obtained from the use of other rating scales of instructional proficiency. These studies of the rating scale for gunnery instructors demonstrated, very early in the gunnery-research program, that rating scales could be used in a standardized manner, providing the raters were properly trained.

Objective examinations were used as another measure of teaching proficiency. An examination in the principles of instruction was given as the final examination in the course in teaching methods at the Instructors School. Questions on the examination presented the student with a hypothetical instructional problem. The student was required to select one of several possible teaching techniques to apply in such a situation. Scores obtained on the Teaching Methods Final Examination correlated approximately zero with scores obtained on the Instructors Rating Scale, described above. Scores from this examination were used as one contributing element in the elimination of students from instructor training, although less weight was given to such scores than to ratings from the Instructors Rating Scale.

Summary

The task of the gunnery instructor was one which presented many difficulties and which required the exercise of a considerable degree of talent and ability. In order to ensure that competent instructors were being furnished to the gunnery-training program, it was necessary that measures of instructional proficiency be established. The best criterion of instructional proficiency would have been based upon some criterion of student performance. Unfortunately, such a criterion of gunnery proficiency was not available for use. This required that instructors be assessed on the basis of characteristics which had presumptive validity for the instructors task. Four such characteristics were selected on the basis of judgment. These were:

1. Intelligence.
2. Gunnery knowledge.
3. Personal adjustment.
4. Teaching proficiency.

Intelligence and gunnery knowledge were measured by the use of objective tests. A rating scale was developed for evaluation of teaching proficiency. Although no measure of personal adjust-

TABLE 12.2.—*Intercorrelations: Ratings on gunnery instructors rating scale in instructors school; practice teaching (Class 44–30; N=132; July 1944)*

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean	SD
1. Appearance		.32	.34	.35	.30	.29	.33	.31	.34	.33	.12	.30	.30	.45	.35	4.46	1.88
2. Voice	.32		.64	.54	.45	.59	.45	.45	.54	.48	.41	.53	.46	.67	.64	4.31	1.89
3. Fluency	.34	.64		.75	.67	.80	.53	.61	.68	.58	.44	.68	.55	.81	.77	4.65	2.15
4. Poise	.35	.54	.75		.65	.75	.57	.56	.66	.58	.47	.62	.68	.82	.72	4.61	1.88
5. Logic	.30	.45	.67	.65		.74	.66	.61	.62	.58	.45	.77	.73	.81	.79	5.23	1.88
6. Ability to express self	.29	.59	.36	.75	.74		.59	.68	.76	.68	.55	.73	.78	.88	.81	4.66	2.06
7. Use of teaching aids	.33	.45	.53	.57	.66	.59		.59	.55	.48	.43	.69	.57	.74	.71	4.63	2.22
8. Originality	.31	.45	.61	.56	.61	.68	.59		.81	.65	.54	.68	.68	.80	.73	3.80	1.97
9. Ability to arouse interest	.34	.54	.68	.66	.62	.76	.55	.81		.72	.55	.70	.71	.82	.77	5.24	1.63
10. Attitude	.33	.48	.53	.58	.58	.68	.48	.65	.72		.53	.58	.55	.76	.67	4.96	1.94
11. Student	.12	.41	.44	.47	.45	.55	.43	.54	.55	.53		.52	.47	.64	.54	4.88	1.80
12. Today's preparation	.80	.58	.68	.02	.77	.73	.60	.68	.70	.58	.52		.74	.83	.83	4.80	1.99
13. Knowledge of subject	.30	.46	.65	.68	.73	.78	.57	.68	.71	.55	.47	.74		.82	.76	4.68	1.49
14. Average of ratings	.45	.67	.81	.82	.81	.88	.74	.80	.82	.76	.64	.83	.82		.90	4.76	1.82
15. General effectiveness	.35	.64	.77	.72	.79	.81	.71	.73	.77	.67	.54	.83	.76	.90		4.37	1.62

ment was obtained, a group judged to be high in this characteristic was identified for use in the validation of tests purporting to measure it.

Although it was not possible to make an experimental determination of the validity of these measures of instructional proficiency, it was judged that their use served the practically important purpose of guiding work in the selection, elimination, and training of gunnery instructors.

SELECTION OF FLEXIBLE GUNNERY INSTRUCTORS

Introduction

Students for the Instructors School were selected from graduates of the basic gunnery schools. Early in 1943, when the first studies of selection were carried out there was extreme variability in the method of selecting basic gunnery graduates who were to become instructors. Table 12.3 indicates the variability of selection in terms of Army General Classification Test scores.

Note that two potential instructors had AGCT scores below 88, and that the range of ability was very great. Table 12.4 shows that the students of the Instructors School varied with respect to scores on an achievement examination which measured gunnery knowledge. Note that Instructor School students from three schools had mean scores below average for basic gunners on the gunnery achievement examination used. Little effort was made to assess the attitudes of students toward becoming instructors.

TABLE 12.3.—*Distribution of Army General Classification test scores for students assigned to the instructors school by each of six gunnery schools (Classes of 43–6 and 43–8, February 1943)*

AGCT score	School represented						Total
	Buckingham	Harlingen	Kingman	Laredo	Las Vegas	Tyndall	
85–88		1				1	2
89–92			1		1		2
93–96		1				2	3
97–100	4		2	1		1	8
101–104	3	3	1	2	2		11
105–108	2		3	2	3	6	16
109–112	4	3	3	3	6	4	23
113–116	3	4	4	7	6	4	28
117–120	4	4	6	6	2	4	26
121–124	2	6	4	6	2	3	23
125–128	4	1	4	2	3	2	16
129–132	1	2	2	5	1	2	13
133–136	3	3	2		1		9
137–140	1	2			1	3	7
141–144		2	1		5	2	10
145–148	1	1			1		3
149–152				1			1
153–156		1		1	1		3
N	32	34	33	33	35	34	204
Mean	117.00	121.79	117.53	119.61	121.24	116.74	119.03
SD	12.84	14.86	11.27	11.45	15.05	13.79	13.45

Table 12.5 shows that of 172 students in the Instructors School, 77 of them did not desire to become instructors. Table 12.6 shows that 92 students of the same group were not interviewed before assignment to the Instructors School; 12 of them were interviewed for 1 minute, and 17 for 5 minutes.[6] The efficiency of a training program is so dependent on the adequacy of its instructors that effort was immediately directed toward improving instructor selection procedures.

Until such time as a thorough selection program could be developed, it was recommended, in April 1943, that all candidates

TABLE 12.4.—*Scores made by instructors school students selected by each of six gunnery schools on a flexible gunnery entrance examination (February 1943, N = 89)*[1] *normed on basic gunnery school students*

School	Mean score	School	Mean score
Buckingham	5.93	Harlingen	4.93
Kingman	5.87	Tyndall	4.52
Las Vegas	5.34	Laredo	3.88

[1] The scores are reported in terms of a 9-point scale, for which a score of 5 is average.

TABLE 12.5.—*Answers to the question: "Did you want to come to the instructors school?" made by students selected to attend the instructors school (Classes 43-8, 43-9, March 1943) by each of six gunnery schools*

Answer	School						Total
	Buckingham	Harlingen	Kingman	Laredo	Las Vegas	Tyndall	
Yes	9	17	17	12	23	17	95
No	13	13	12	19	7	13	77
Total	22	30	29	31	30	30	172

TABLE 12.6.—*Length of interview prior to assignment reported by students selected to attend the instructors school by each of six gunnery schools (Classes 43-8, 43-9, March 1943)*

Time (in minutes)	School						Total
	Buckingham	Harlingen	Kingman	Laredo	Las Vegas	Tyndall	
No interview	16	17	2	27	7	23	92
1	1	2	7	1	1		12
5		2	8	3	4		17
10	1	3	2		8		14
15-25	2	3	7		5	2	19
30-55		1	4		5	1	11
60 and above		1				3	4
Total	20	29	30	31	30	29	169

[6] This study was conducted by Capt. Mason Haire and Sgt. Ardie Lubin, in March 1943.

for the Instructors School be carefully interviewed, and that a minimum Army General Classification Test score of 120 be required for admission to the school. Some doubt was expressed whether this AGCT requirement could be met. In order to determine whether or not an AGCT score of 120 was a feasible requirement, a study was conducted to ascertain the AGCT scores of instructors and students at all the basic gunnery schools. Table 12.7 shows the mean AGCT scores of all instructors. Only 2 schools, the Instructors School and Harlingen, showed mean AGCT scores above the recommended score of 120. However, it was found that of a population of 2,629 basic gunnery students, 22.75 percent had AGCT scores over 120, indicating that a sufficiently large group was available from which to select candidates for the Instructors School. Figure 12.1 depicts, graphically, the results of this study.[a]

Following this study a directive was issued by the AAF Training Command which required that all candidates:

a. be a graduate of an Army Air Forces Training Command Flexible Gunnery School, except in the case of qualified student officers;

b. have an AGCT score of 120 or above, or in exceptional cases of 110 to 119. Exceptional cases are defined as students with AGCT scores of 110 to 119 who have special training such as combat, teaching experience, or 4 years of college training at a recognized college or university, which will compensate for their somewhat lower general ability;

c. have qualified within the past 2 months on the Gunnery School Comprehensive Final Examination or on the Instructors Qualifying Examination with a score which indicates mastery of the subject matter of flexible gunnery to a point above that obtained by 75 percent of regular gunnery students;

d. be a high school graduate;

e. have the general attributes and attitudes desirable in the task as determined by a competent interviewing officer.

The directive served to fix interim policy on instructor selections; meanwhile a project was initiated for the development of an instructors' selection battery which would ensure a relatively homogenous population for the Instructors School with respect to characteristics related to success. The remainder of this chapter is concerned with a description of the task of constructing an

TABLE 12.7.—*The average AGCT scores of instructors in the six basic gunnery schools and in the instructors school (N= 3780, November 1943)*

School	N	Average AGCT score
CIS instructors	119	119.6
Harlingen	678	122.1
Las Vegas	770	128.2
Buckingham	593	119.3
Tyndall	648	117.9
Laredo	491	117.5
Kingman	483	116.4

[a] This study was done by Capt. Lawrence M. Stolurow.

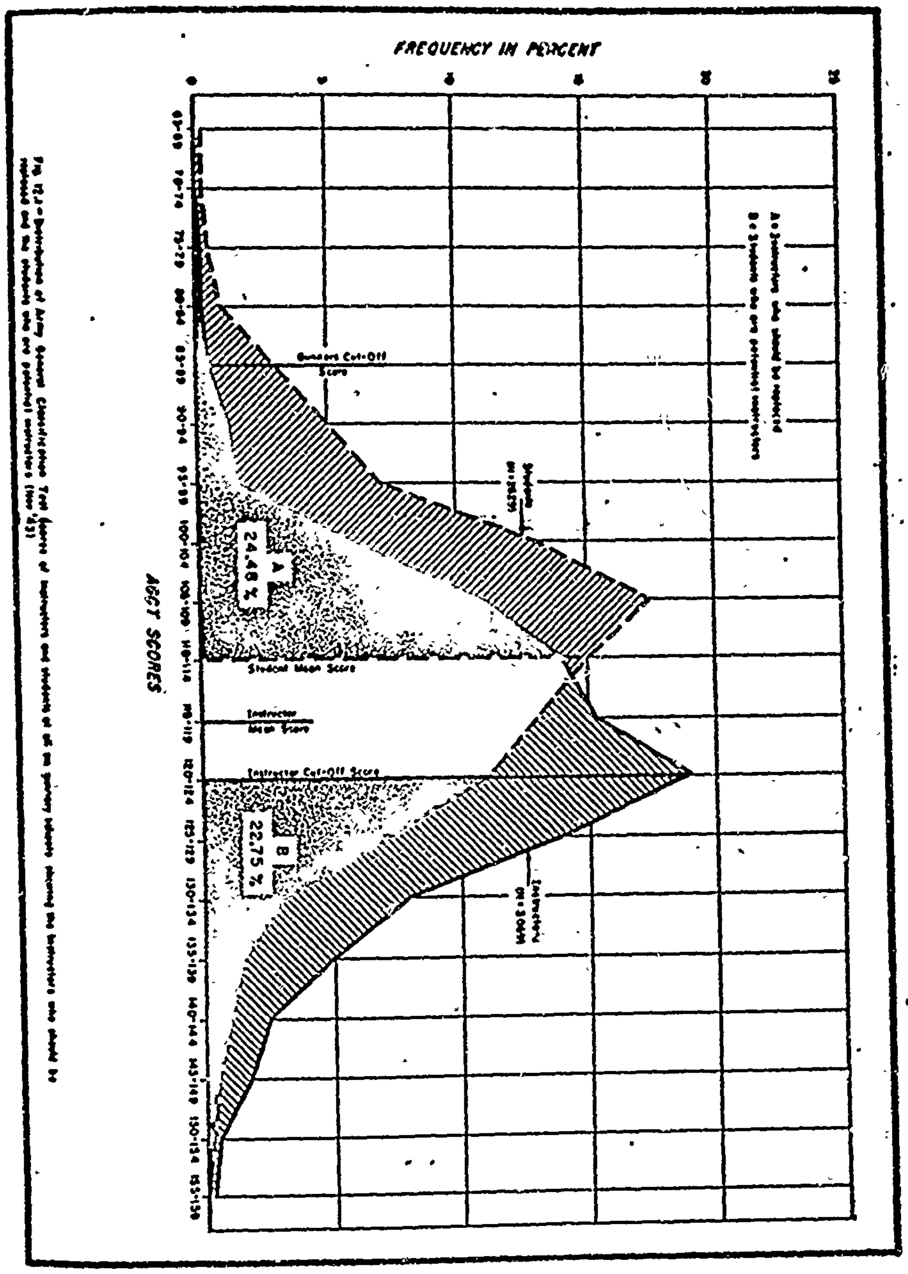

Fig. 12.3 — Distribution of Army General Classification Test Scores of instructors and students at all air gunnery schools showing the instructors who should be replaced and the students who are potential instructors (Nov '43)

instructors' selection battery, and with an indication of the practical use of this battery in selection and in research.

The Construction of the Instructors Qualifying Examination Battery

The problem.—There were two measurable aspects of success in the Instructors School: One, knowledge of flexible gunnery subject matter as measured by the Instructors Final Comprehensive Examination; two, teaching ability as measured by the Gunnery Instructors Rating Scale. The specific task of the test constructors was to develop a battery of tests which would reliably predict success in the school as measured by these two criteria.

Exploratory and incomplete attempts at test development.—Before describing the tests used in the final battery, there will be presented an account of various tests considered for possible inclusion in the Instructors Qualifying Examination battery. In exploring possible approaches to the measurement of teaching aptitude, of interest in teaching, and of personal adjustment, many tests were developed and tried out experimentally with varying degrees of success. Time was an important consideration limiting the extent of studies. In several cases tests were developed which contained items with satisfactory validity coefficients under specific circumstances, but when tried out with different classes much variability was found. It was necessary to abandon such tests and to devote the available time and personnel to the development of instruments less sensitive to variations.

The first test to be tried for this purpose was the Opinions on Instructing Test. This test was developed by the Aviation Psychology Section, Bureau of Medicine and Surgery, United States Navy.[10] The test, originally called "Opinions on Teaching," was revised slightly to conform to vocabulary in use in the flexible gunnery program and was renamed "Opinions on Instructing." The test was designed to measure opinions regarding instructional techniques, and it was felt that it might predict teaching proficiency. Illustrative items from the test are presented below.

Directions:—Below are a number of statements expressing opinions on instructing. They are statements on which instructors differ greatly among themselves. You are asked to indicate the extent to which you agree or disagree with each of the statements. Please give some response to each of the items. Use the following scale: (a) Strongly disagree; (b) disagree; (c) undecided; (d) agree; (e) strongly agree.

1. Students should be on time to the minute for each class.
2. The good instructor spends most of the class period dictating notes to the students.

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[10] The evaluation of this test was accomplished by Capt. Wilbur S. Gregory and Lt. Thomas P. Gallagher.

3. No matter what rule a student breaks, he should be reported to the supervisor or C.O.

4. Ordinarily, an instructor should not talk more than half the time during a class period.

The test was administered to basic gunnery students, to Instructors School students, both at the time of entrance and at the time of graduation from the Instructors School, and to the instructors in the Instructors School, in order to obtain a rough index of the validity of the test. The original key, which designated 1 answer among 5 as correct, presumably on an a priori basis, was used. Score was total rights. The data presented in table 12.8 indicate that the differences found were significant statistically in the correct direction, but that they were too small for practical application.

For a better measure of the validity of the opinionnaire, scores were correlated with ratings on the Gunnery Instructors Rating Scale, using class 43–15, totaling 124 students. The product moment correlation coefficient was found to be 0.10. In view of this low validity and the relatively low reliability (see table 12.8) it was decided not to conduct further studies in an attempt to develop this test for a selection device.

A second test which was considered promising was the Teaching Principles Examination. This examination was originally developed as a course examination for teaching methods.[11] The nature of the items of the examination was such that it seemed worthwhile to consider the examination for possible use in predicting teaching aptitude. For the purpose of this discussion it is sufficient to note that items in this test were centered around practical teaching situations and were indicative of attitudes and knowledge of teaching principles and practices. The correlation was determined between scores on the examination and two criteria of success in the Instructors School, the Instructors Final Comprehensive Examination, and ratings in Practice Teaching. Using Instructors School class 44–29, consisting of 120 students, the scores of the Teaching Principles Examination correlated 0.12 with Practice Teaching ratings and 0.04 with scores on the Instructors Final Comprehensive Examination.

The two tests considered thus far, the "Opinions on Instructing Test" and the "Teaching Principles Examination," had several elements in common. They both contained items expressive of attitudes and opinions toward teaching principles and practices, and both seemed heavily weighted with a verbal factor. Experience with these two tests suggested that the ability to teach

[11] This test was developed by Lt. Joseph M. Wepman.

related to the ability to verbalize about these methods and techniques.

TABLE 12.8.—*Reliability coefficients and critical ratios between mean scores on the Opinions on Instructing test using basic gunnery students, Instructors School students, and Instructors School instructors (July 1943)*

Group No.	Group studied	Phase of training	N	M	SD	r[1]	Critical ratios between groups
1	Basic gunnery[3] (Class 43-29)	Graduate	295	35.12	5.67	0.42	1 v 2 = [2] 5.07 1 v 3 = [2] 4.36 1 v 4 = [2] 2.25 1 v 5 = [2] 3.87
2	Instructors school (Class 43-15)	Graduate	106	38.18	5.17	.87	2 v 3 = 1.02 2 v 4 = [2] 5.52 2 v 5 = .82
3	Instructors school (Class 43-16)	Entering	95	37.66	6.66	.58	3 v 4 = [2] 6.32 3 v 5 = 1.06
4	Instructors school (Class 43-16)	Graduate	107	41.88	4.55		
5	Instructors school (Instructors)		52	39.15	6.89	.61	

[1] Based on Kuder-Richardson Formula No. 21.
[2] A difference of this magnitude would be expected in less than 1 time in 100.
[3] Laredo.

Personal Adjustment Inventory.—The use of returned combat gunners as instructors on flexible gunnery training stations made it necessary to consider the adjustment of men selected for the Instructors School. For this reason, the Personal Adjustment Inventory was constructed. It was patterned after the Personal Inventory, DE201C, but greater emphasis was placed on disguising the "right" responses. The original test contained 60 items, samples of which are presented below.

1–A. I have a tendency to become nervous and shaky when approached by a superior officer.

2–A. When people meet for the first time on a party it eases things a bit if a drink is passed around.

3–A. I always seem to have a bad time, no matter what I am doing.

4–A. I am often too tired and exhausted even to eat.

1–E. I sometimes have headaches.

2–E. Normal, well-balanced people don't need a drink to get acquainted.

3–E. I often have difficulty in falling asleep.

4–E. I don't make friends very easily.

Experience with gunners had indicated that there was some tendency among them to falsify personal adjustment inventories with obvious answers. In order to get a more accurate estimate of adjustment it was felt that items should be so combined that the average gunner would not be able to pick the "correct" responses.

The test was administered anonymously to 300 instructors of the Instructors School, half of whom took the Personal Inventory, DE201C, and half of whom took the Cornell Selected Index. An item analysis showed that, of the 60 items, 41 discriminated between high (upper 27 percent of cases) and the low (lower 27 percent of cases) groups on either the Personal Inventory or the Cornell Selectee Index, with at least a discrimination index (chi-square) which would have been expected to occur by chance less than 5 times in 100.[12] The correlation with the Personal Inventory was 0.58 and with the Cornell Index was 0.31.

Further work on the Opinions on Instructing Test and the Personal Adjustment Inventory might have yielded materials which would have been useful in the final battery. However, the work was stopped at this point.

Description of tests used in the final battery.[13] The first area chosen for inclusion in the final battery was gunnery knowledge. Items which measured gunnery knowledge were selected from gunnery final examinations used in basic schools. Revision of gunnery knowledge items kept pace with new delevolpments in gunnery when these were introduced into the curriculum of basic schools.

The construction of a battery of tests to cover the area of gunnery knowledge presented a special problem in that each candidate for the Instructors School had been trained on one gun position. Therefore, it was necessary to give the student an opportunity to answer these test items which were concerned with his gun position. Consequently, in addition to items covering gunnery knowledge which all students had in common, there had to be a choice of items covering specialized gun positions. There were, in all, 90 items on gunnery knowledge. Of these, 70 were devoted to questions about aircraft recognition, sighting, and weaepons. Twenty were devoted to each of the following gun positions: Martin turret, Consolidated turret, Sperry Lower Ball turret, Sperry Upper Local turret, Bendix Upper turret, Bendix Chin turret, Emerson Nose turret, M–6A and M–7 gun mounts, and B–29 turrets. Each student answered all 70 general items and then selected the remaining 20 items dealing with the gun position he knew best.

[12] This project was conducted by Capt. Lawrence M. Stolurow and Lt. Gerald R. Pascal.

[13] This battery of tests was developed by a group of officers and enlisted men working over a 2-year period. Those chiefly responsible were: Capt. Lawrence M. Stolurow, Capt. Alfred C. Jensen, Lt. Gerald R. Pascal, Lt. William B. Schrader, Staff Sgt. Robert G. Bainbridge, Staff Sgt. Marvin Waldman, Sgt. Paul Freeman, and Cpl. Herbert W. Goldstrom. Statistical assistance was given by Maj. John V. McQuitty, Lt. William H. Angoff, and Staff Sgt. Hyman B. Kaltz.

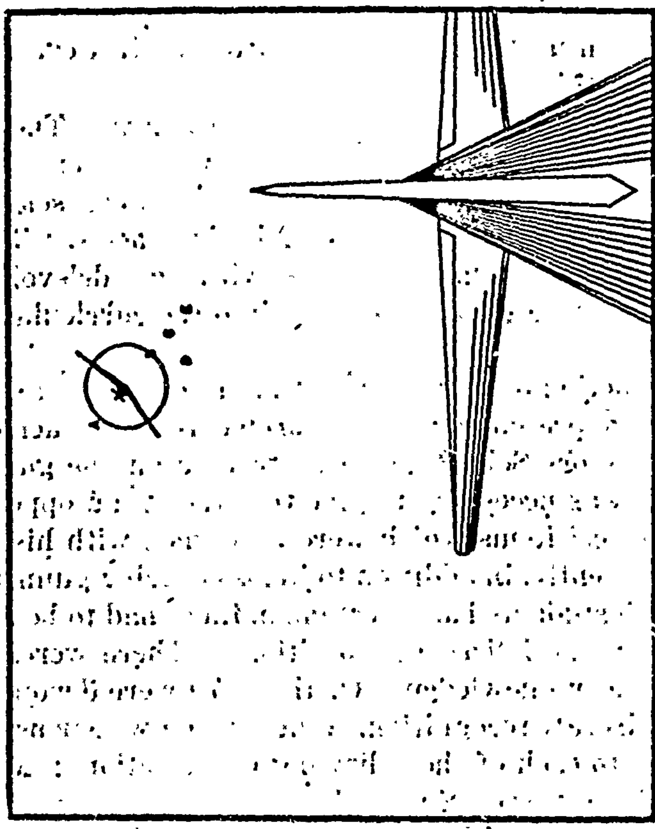

Fig 12.8 – Illustrated Item No 2, Lighting, CSPB Qualifying Examination (Achromatic)

Illustrative Item 1.—Aircraft Recognition.

Directions.—This part of the examination contains a group of pictures of both friendly and enemy aircraft similar to those which gunners see in the different theaters of operation. Below each picture are five names of different aircraft. You are to select the choice that you think is correct and mark the answer on your separate answer sheet.

(Inserted here were photographs of planes in flight, each photograph being the basis of a multiple-choice item made up of names of fighter planes.)

Illustrative Item 2.—Sighting.

Directions.—For the next 7 questions, imagine yourself in a bomber having a true air speed of 225 m.p.h. Your gun position is equipped with an N-6 optical sight which has a 70 mil reticle, which can be seen drawn on each plane pictured below. You are to indicate the proper deflection in order to hit the attacking plane by marking the correct letter on your answer sheet.

Shooting from the top turret position in figure 12.2 you would aim at point lettered A, B, C, D, E.

Illustrative Item 3.—Weapons.

There is a strong click and no dent in the primer (of the cal. .50 machine gun). The probable cause is a

3–A. broken or weak firing-pin spring
3–B. broken sear notch
3–C. broken firing-pin striker
3–D. slightly worn firing-pin striker
3–E. slightly bent up trigger bar.

Illustrative Item 4.—B–29 turrets.

If the actual wing span of an attacking plane is smaller than the dial setting seen in the optic head,

4–A. let the fighter's wing tips overlap the reticle circle a little.
4–B. keep the reticle circle a little beyond the fighter's wing tips.
4–C. frame correctly, but place the center dot above the fuselage of the fighter.
4–D. frame correctly, but place the center dot halfway between the fuselage of the fighter and the tip of the wing toward your bomber's nose.
4–E. frame correctly, but place the center dot halfway between the fuselage of the fighter and the tip of the wing toward your bomber's nose.

The second main area included measures of general intelligence and mechanical tiptude. Construction of this section consisted principally of selecting suitable items from other tests, particularly the Gunnery Officers Selection Test (see chapter 13), and by writing new items considered appropriate to instructors. These items were assembld into subtests, administered to a group of students, and the test was shortened by means of an internal consistency item analysis. Five subtests were included in this part of the battery. Examples from each of these are given below.

Illustrative Item 5.—Vocabulary.

An enclosed shelter for personnel or for a power plant in aircraft is a (an)

5–A. housing.
5–B. canopy.
5–C. nacelle.
5–D. enclosure.
5–E. cowling.

Illustrative Item 6.—Mechanical Aptitude.

The initial velocity of a bullet fired from a tail gun at a small angle from the line of flight will be slightly

6–A. less than the sum of the plane's velocity plus the muzzle velocity.
6–B. less than the muzzle velocity.
6–C. less than the muzzle velocity minus the plane's velocity.
6–D. more than the muzzle velocity, minus the plane's velocity.
6–E. more than the sum of the plane's velocity plus the muzzle velocity.

Illustrative Item 7.—Mathematics.

A sniper stands in a room 8 feet back of a wall that contains a window 4 feet wide. On a road 100 feet from the house and parallel to it, an infantry column is marching past. The length of the column that the sniper can see is

7–A. 50 feet.
7–B. 54 feet.
7–C. 100 feet.
7–D. 108 feet.
7–E. 200 feet.

Illustrative Item 8.—Reading Comprehension.

Any mechanical system tends to come into the position in which its potential energy is a minimum. Thus, bodies free to move fall to the ground; and the surface of a liquid is horizontal because it cannot be tilted without raising the center of gravity of the liquid and so increasng the potential energy. When a molecule moves from the interior to the surface of a liquid, work must be done on it. A surface molecule, therefore, has greater potential energy than an interior molecule. Consequently, the substance tends to get into the state in which it has the smallest surface.

It frequently happens that this tendency is overcome by other influences. Thus, if water is spilt on the ground, it does not collect into a sphere but spreads out. In this case the tendency towards minimum gravitational potential (lowering of the center of gravity) overcomes that towards minimum surface energy, and the liquid takes the form in which the total potential energy is least. If the amount of water is very small, however, so that very little loss of gravitational energy is achieved by spreading, surface tension becomes dominant, and the liquid collects into a sphere. It may be calculated that water drops less than two or three millimeters in radius will remain spherical and will not spread.

The surface of a liquid is level because any degree of tilt would result in

8–A. increased gravitational potential.
8–B. increased surface area.
8–C. decreased surface tension.
8–D. increased surface tension.
8–E. increased number of surface molecules.

Illustrative Item 9.—Surface Development.

In figure 12.3, edge 2 corresponds to

9–A. l.
9–B. m.
9–C. s.
9–D. t.
9–E. K.

The third main section of the battery included items on teaching aptitude and personal adjustment. These two areas were at first divided into two subtests, but in the final form, items aimed at both areas were grouped together into one subtest called "Teaching Aptitude." Items were chosen from various tests in use in the aviation cadet classification and selection program, from

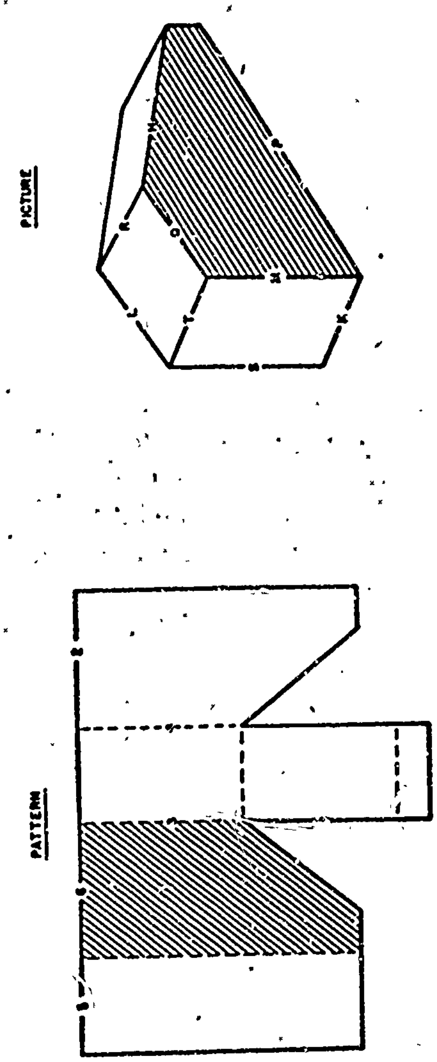

Fig. 123—Distinctive Item No. 8, Surface Development, CAFS Qualifying Examination (Aptitude)

the Personal Inventory, DE201C, and from the Opinion Poll. Many new items were constructed. Several hundred items of all sorts were tried against the criterion of ratings on the Gunnery Instructors Rating Scale as administered in the various teaching situations. This test went through several revisions.

The first attempt made in this direction was the development of the Instructors Preference Test, which consisted of 118 personality items designed to measure some of the general aspects of personality which were considered to be important in determining success in teaching. Forty items of the test were designed to measure the general affective nature of the individual. Thirty-five items were designed to measure certain aspects of the individual's early training and family background. The remaining 43 items were concerned with the individual's occupational and social participation. This test was administered to class 44–27 in the Instructors School, consisting of 126 students, and an item validation with high-low groups in Practice Teaching, as measured by the rating scale, was performed. This analysis resulted in 17 satisfactory items.

An additional 43 items were added to the 17 obtained in the original investigation in an effort to build up a pool of items to increase the reliability of this part of the battery. The new group of items was obtained from several sources, the chief of which was the Opinion Poll. The 60 item test was administered to Instructors School class 44–29, consisting of 140 students. A correlation coefficient of 0.11 was obtained between scores and ratings in Practice Teaching. About the time of this study (August 1944) ratings on a course in Student Teaching were introduced as an additional criterion of teaching ability in the Instructors School. Therefore, in the subsequent item validation of the 60-item test, Student Teaching ratings as well as Practice Teaching ratings were used as criteria. Using these 2 criteria, 40 valid items were found; 31 for Practice Teaching ratings and 9 for Student Teaching ratings. The Practice Teaching and Student Teaching ratings were combined as criteria against which to validate the 40 items thus obtained.[14]

It can be seen from the above that the teaching aptitude test

[14] To be high in the combined criterion, the candidate had to be high in Practice Teaching (rating of 7, 8, or 9) and not low in Student Teaching (rating of 1 or 2), or high in Student Teaching (rating of 4 or 5) and not low in Practice Teaching (rating of 1, 2, or 3); to be low in the combined criterion, the candidate had to be low in Practice Teaching (rating of 1, 2, or 3) and not high in Student Teaching (ratings of 4 or 5), or low in Student Teaching and not high in Practice Teaching. Subjects not meeting either of these requirements were put in the middle category of the combined criterion. On the combined criteria the following number of cases in each of the three groups from class 44–29 were obtained: high in combined criterion, 34; medium in combined criterion, 61; low in combined criterion, 29.

which was finally used in the battery was the outcome of several attempts to obtain valid items in a relatively unstable situation. It was never possible to use larger samples of classes for item validation studies for the prediction of teaching ability, since the methods of assessing that ability in the school varied considerably, and also because the demand for an instructor selection battery was immediate.

Illustrative items for the Teaching Aptitude subtest.—Several items used in the subtest on Teaching Aptitude are presented below, with directions for the test.

Directions.—In this part you will give information about your past experience, your preferences, and your interests. In each question you will choose between two answers which will be designated by A and E. You must choose the one which fits you better than the other. Blacken the appropriate space, A or E, on your answer sheet, to indicate the alternative which more nearly fits your own case. There are no right or wrong answers. Though you may feel that a particular item does not apply to you, choose the one response that fits you better than the other. Do not omit any item.

Illustrative Item 10.

I honestly think that in assigning me as a gunnery instructor the Army is making good use of my abilities.

10–A. Agree. 10–E. Disagree.

Illustrative Item 11.

I enjoy talking before a small group.

11–A. Agree. 11–E. Disagree.

Illustrative Item 12.

12–A. Being bossed around annoys me.

12–E. Most people need firm supervision.

Illustrative Item 13.

13–A. In school I liked to be by myself.

13–E. In school I preferred to be with a gang.

Illustrative Item 14.

14–A. A thorough and logical presentation of the subject matter, even if somewhat dry, is the more effective teaching method.

14–E. An interesting presentation of the subject matter, although somewhat incomplete, is the more effective teaching method.

Total test: format, distribution constants, and reliabilities.—The Instructors Qualifying Examination (form E) as finally used consisted of two booklets. A third booklet, on mechanical comprehension, was added for use at AAF Personnel Distribution Command stations, but little data obtained from its administration are available. Table 12.9 shows the format of the examination, with the number of items in each part. Although time limits were suggested for each subtest, the examination was not considered a speed test. Students were allowed to complete the

examination regardless of time. The achievement booklet typically consumed an hour, the aptitude booklet, an hour and a half.

Tables 12.10 and 12.11 show the reliabilities and distribution constants of booklet I and booklet II, respectively. It will be noted that data on certain gun positions and turrets are missing from these tables. The A-26 and B-29 turrets were new at the time of test construction. Items covering knowledge of these turrets were added to meet a demand created by the return of some of these gunners from the overseas theaters and by a need in the training program. At the time of the study of reliability, it was impossible to obtain scores from a sufficient number of students of these turrets to compute reliabilities.

TABLE 12.9.—*Format of CSFG Qualifying Examination*

Booklet and code	Part No. and name	Number of items	
Booklet I (DS 304E)	I. Vocabulary	20	
	II. Mechanical principles	12	
	III. Mathematics	18	
	IV. Reading comprehension	10	
	V. Surface development	15	
	VI. Inventory	40	
			115
Booklet II (DS 461E)	I. Aircraft recognition	15	
	II. Sighting	25	
	III. Weapons	30	
	IV. Turrets [1]	20	
			90
Booklet III (DS 201A)	Mechanical comprehension		40
	Total		245

[1] Turrets included: Martin, Consolidated, Sperry Ball, Sperry Upper, Bendix Upper, A-26, Bendix Chin, Emerson Nose, M-6A and M-7 Gun Mounts, and B-29 Turrets.

The Validity of the Instructors Qualifying Examination.—The determination of the validity of the Instructors Qualifying Examination was complicated by the nature of the criteria against which the test had to be validated. As has been previously stated, the test was constructed to predict two specific criteria of success in the Instructors School, gunnery knowledge and teaching aptitude. Gunnery knowledge was measured by the Instructors School Final Comprehensive Examination. The reliability of this examination was known, and its use as a basis of elimination in the Instructors School was constant during the period of test construction. The limitations of the teaching aptitude criterion have been discussed. All validity coefficients are product-moment correlation coefficients.

Booklet I (aptitude) and Booklet II (achievement) were developed to be used separately; separate stanines were determined for each booklet (see table 12.12).

Since the Instructors School was training instructors for both

TABLE 12.10.—*Reliability coefficients and distribution constants, Instructors Qualifying Booklet I (aptitude) by parts and by total scores (N = 800, 5 PDC Redistributing Stations, January 1945)* [1]

Part	No. of items	r [2]	r [3]	M	SD
I. Vocabulary	20	0.66	0.69	8.32	3.63
II. Mechanical principles	12	.55	.59	5.57	2.44
III. Mathematics	18	.66	.72	9.50	3.43
IV. Reading comprehension	10	.48	.54	4.41	2.08
V. Mechanical aptitude	15	.82	.84	11.08	3.48
VI. Inventory	40	.61	.67	22.69	4.95
Total	115	.82	.85	61.56	12.35
Mechanical principles	40	[4].22		5.27	2.42

[1] Papers from Miami Beach, Atlantic City, Santa Monica, and Santa Ana.
[2] Kuder-Richardson Formula No. 21.
[3] Kuder-Richardson Formula No. 20.
[4] This correlation based on 310 cases from Santa Ana, Atlantic City, and Miami Beach Redistribution Stations.

locally controlled turret schools and for remotely controlled turret schools, and since separate final comprehensive examinations were used to determine the graduation or elimination of the two groups of students, it was considered desirable to determine whether a reliable difference in validity cofficients occurred for the two groups. The t's of the differences between the validity coefficients found with the parts of the Instructors Qualifying Examination for the two groups are presented in table 12.13. This result was interpreted to indicate that the two groups might well be combined in further statistical analysis.

Table 12.14 shows the validity coefficients found with each of the criteria by booklets. The correlations shown in this table were computed using raw scores on the Instructors Qualifying Examination and scores obtained in the Instructors School on

TABLE 12.11.—*Reliability coefficients and distribution constants, Instructors Qualifying Examination Booklet II (achievement) by parts* [1] *and by total* [2] *scores (3 PDC Redistribution Stations, January–March 1945)*

Part	No. of items	N [3]	M	SD	r [4]
I. Aircraft:					
Recognition	15	2329	7.80	2.66	0.50
II. Sighting	25	2329	8.90	3.44	.54
III. Weapons	30	2329	13.36	4.45	.55
IV. Turrets:					
Martin	20	812	7.95	2.95	.47
Sperry upper	20	394	7.98	3.33	.60
Sperry ball	20	643	9.61	3.43	.62
Bendix	20	155	6.92	2.85	.47
Consolidated	20	401	9.39	3.29	.67
Total (Parts I–IV):					
Martin	90	812	37.11	9.70	.78
Sperry upper	90	394	39.37	10.25	.86
Sperry ball	90	643	40.34	10.36	.80
Bendix	90	108	33.93	9.93	.79
Consolidated	90	267	38.70	9.95	.78

[1] All papers used regardless of turret answered.
[2] Papers sorted by turret answered.
[3] Papers from Miami Beach, Santa Monica, and Atlantic City.
[4] Kuder-Richardson Formula No. 21.

each of the criteria. All scores on the criteria were converted scores based on a nine point scale using stanine percentages with the exception of Student Teaching which was evaluated using a five point scale. The correlation coefficients were corrected for restriction in range of the selection test.[15]

TABLE 12.12.—*Separate stanine distributions for Booklet I and Booklet II, CSFG Qualifying Examination (November 1944)*

Stanine	Percent of Population	Booklet I—Raw score		Booklet II—Raw score	Total test [4]—Raw score
		Part I–V [1]	Part VI [2]	Total [3]	
9	4	[5] 58	[5] 29	[5] 71	[5] 157
8	7	52–57	27–28	66–70	142–156
7	12	47–51	25–26	61–65	129–141
6	17	42–46	23–24	56–60	92–103
5	20	37–41	21–22	50–55	104–115
4	17	32–36	19–20	44–49	116–128
3	12	26–31	16–18	38–43	81–91
2	7	21–25	12–15	29–37	70–80
1	4	[6] 20	[6] 11	[6] 28	[6] 69

[1] Mean= 38.22; SD= 9.73; N= 1266.
[2] Mean= 20.83; SD= 4.82; N= 1266.
[3] Mean= 51.69; SD= 11.67; N= 703.
[4] Includes Mechanical Comprehension Test (DS201A).
[5] And above.
[6] And below.

The Instructors Qualifying Examination correlated fairly satisfactorily with the Final Comprehensive Examination, but rather poorly with the criteria of teaching ability. The correlation coefficients of Booklet I with the criteria of teaching ability are all of such magnitude that coefficients of the size obtained would be expected to occur less than 1 time in 100 by chance. There was, however, considerable variability in the validity of Booklet I (aptitude) particularly with respect to the criterion of teaching ability, ratings in Practice Teaching. Table 12.15 shows how validity coefficients for Booklet I varied from class to class. Subtest VI, Teaching Aptitude, varied markedly in validity against the Practice Teaching criterion. Table 12.16 shows the intercorrelations of Booklet I subtests based on the scores of 323 Instructors School students.

The Instructors Qualifying Examination in Practice

Use in Personnel Distribution Command Stations.—Beginning late in November 1944, all gunners passing through the AAF

[15] The correction applied used the standard deviation of the total score on the Instructors Qualifying Examination computed from the stanine conversion table in use by the Personnel Distribution Command as an estimate of the dispersion in an unrestricted sample. This value was 26.250; the corresponding value for the restricted range being 17.221. The formula for correcting coefficients between two variables in a population restricted with respect to a third variable is given in report No. 3 of this series.

Personnel Distribution Command were given the Instructors Qualifying Examination battery.

TABLE 12.13.—*t's of the differences between the validity coefficients of CSFG Qualifying Examination part scores with the total score on the Instructors School Final Comprehensive Examination for the locally controlled and remotely controlled turret students (N= 675, Laredo, July 1945)*

Part	r Local control (N= 491)	r Remote control (N= 184)	(Z score) diff.	t	Probability (percent)[1]
Vocabulary	0.206	0.335	0.135	1.56	12
Mechanical principles	.388	.321	.079	.91	38
Mathematics	.405	.342	.076	.88	38
Reading comprehension	.318	.232	.098	1.13	28
Surface development	.207	.164	.041	.47	64
Teaching aptitude	—.102	—.054	.045	.52	60
Aircraft recognition	.170	.148	.026	.30	77
Sighting	.342	.361	.023	.27	79
Weapons	.448	.399	.060	.69	49
Turrets	.295	.194	.106	1.23	22

[1] The numbers indicate the number of times in 100 that the differences found could be expected to occur by chance.

TABLE 12.14.—*Validity of CSFG Qualifying Examination, by booklets, against each criterion of success in the Instructors School (Classes 215, 225, 235; N= 800, February 1945)*

Criterion	Booklet I[1]	Booklet II[1]
Criterion		
Final comprehensive	0.57	0.62
Basic gunnery teaching	.24	.12
Practice teaching	.19	.08

[1] Product-moment correlation coefficients.

Stanine conversion tables based on an unselected population were furnished to the redistribution stations. Investigations of the relationships among the criteria (see table 12.17 for a state-

TABLE 12.15.—*Validity coefficients of parts of the Instructors Qualifying Examination, Booklet I (Aptitude), with the Final Comprehensive Examination and with practice teaching ratings using three Instructors School classes (August 1944)*

Subtest	Validity coefficients by class							
	Final comprehensive				Practice teaching			
	44–29 N=120	44–31 N=102	44–32 N=101	3 Classes N=323	44–29 N=120	44–31 N=102	44–32 N=101	3 Classes N=323
I. Vocabulary	0.12	0.41	0.40	0.31	—0.05	—0.04	—0.04	—0.05
II. Mechanical principles	.42	.42	.52	.45	.07	—.05	—.12	—.03
III. Mathematics	.14	.34	.34	.28	—.06	—.02	—.01	—.01
IV. Reading comprehension	.22	.50	.48	.40	.05	.00	—.07	.00
V. Surface development	.29	.36	.31	.31	—.06	—.13	—.02	—.06
VI. Teaching aptitude	—.03	—.04	.03	—.01	.38	.16	.38	.30

TABLE 12.16.—*Intercorrelations of part scores of the Instructors Qualifying Examination, Booklet I (Aptitude), using three Instructors School classes (N= 323, August 1944)*

Part	Part					
	I	II	III	IV	V	VI
I. Vocabulary	--------	0.43	0.28	0.49	0.18	−0.05
II. Mechanical principles	0.48	--------	.46	.49	.28	−.19
III. Mathematics	.28	.46	--------	.35	.36	−.11
IV. Reading	.49	.49	.35	--------	.34	−.18
V. Surface development	.17	.28	.36	.34	--------	.03
VI. Teaching aptitude	−.05	−.19	−.11	−.18	.03	--------

ment of these relationships) indicated that the criteria showed rather low intercorrelations. It was recommended that separate stanine cut-off scores on the two booklets be used to select instructors. Separate cut-off scores were used in the reclassification of instructors, described later on in this chapter, and separate stanine cut-off scores were recommended for use in the Personnel Distribution Command; however, the use of the recommended procedure in the Personnel Distribution Command stations was not feasible.[16]

Table 12.12 shows the stanine conversion tables used by the Personnel Distribution Command. It will be noted that these stanines are based on the total score using both booklets of the Instructors Qualifying Examination, and the score on the Mechanical Comprehension Examination (DS201A). All men with stanine scores of five or better on the entire battery were sent to the Instructors School for the regular course of instruction.[17]

The Mechanical Comprehension Examination (DS201A), developed at Santa Ana, was added to the Instructors Qualifying Examination battery for the following reasons: (a) the early validation studies of the battery showed that the Mechanical Principles subtest had one of the most satisfactory validity coefficients with the Final Comprehensive Examination (see table 12.15); (b) this subtest also showed relatively low correlation coefficients with the other tests in the battery (see table 12.16). It was therefore decided, in a conference including personnel of the Surgeon's Section of the AAF Personnel Distribution Command and members of the Research Division, that the Mechanical Comprehension Examination (DS201A) be added to the battery.

The reliability coefficients and intercorrelations of the Mechanical Comprehension Examination with subtests of the Instructors Qualifying Examination and with the criteria are presented in

[16] See table 12.12 for the table of recommended stanines.

[17] See report No. 14 of this series for additional details regarding the method of administration, the number tested, and a description of the processing.

table 12.17. This table shows, in addition, the validity of the entire battery as used by the Personnel Distribution Command. Note that with this population, validity coefficients, using single scores on the entire Instructors Qualifying Examination battery, are 0.62 with the Instructors School Final Comprehensive, 0.13 with Practice Teaching, and 0.21 with Student Teaching.[18]

Use in research.—The Instructors Qualifying Examination was used in a research study to assess the efficiency of the placement program in the AAF Training Command basic gunnery schools with respect to instructors. The examination battery was administered to instructors at five of the seven basic gunnery schools. Two separate scores were derived from Booklet I (aptitude). A score was determined for each instructor, based on his performance on parts I through V, and another score in part VI. For Booklet II (achievement), answer sheets were scored on the basis of total scores as well as of each of the four part scores (Aircraft Recognition, Sighting, Weapons, and Turrets). Tables 12.18 and 12.19 show the results of an analysis of variance of these data.

The Instructors Qualifying Examination was administered to unselected graduates of basic gunnery schools for the purpose of obtaining data which might provide a basis for estimating the relative efficacy of basic gunnery schools and the assignment of gunners to various turret positions. Test scores were treated in the same manner as those obtained from instructors, and an analysis of variance computed. Tables 12.20 and 12.21 show the results of this analysis.[19]

These studies indicated that there was no noticeable difference, on the basis of performance on the Instructors Qualifying Examination, between instructors who had attended the Instructors School and those who had not. Between schools, however, there was noticeable variation of test scores, both for instructors and students. For instructors, the found differences between departments was so great as to be expected to arise by chance less than 1 time in 100. There was also a similar difference between student scores compared on the basis of turret studied. These facts indicated that some selective factors were operating to send more qualified instructros to particular schools. This also applied to students. Within a particular school a similar situation existed in the assignment of instructors to departments and students to turrets.

Factor analysis of the Instructors Qualifying Examination.—

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[18] This study was done by Capt. Lawrence M. Stolurow and Lt. Paul Freeman.

[19] This study was done by Capt. Lawrence M. Stolurow, Capt. Kenneth B. Henderson, and Sgt. Ernest E. Ketchersid.

TABLE 12.17.—*Validity coefficients, intercorrelations, and coefficients of reliability of the CSFG Qualifying Examination Battery and three criteria including part and total scores (N= 675, July 1945)*

Variable	Variable No.	M	SD	Variables[1] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
IC final comprehensive:																									
Weapons	1	7.31	3.80	(64)	56	48	30	29	80	17	01	34	47	39	34	30	03	46	26	42	61	42	59	44	60
Sighting	2	7.28	3.02	56	(41)	42	45	38	79	20	13	41	45	54	31	31	-02	53	30	54	47	37	56	46	62
Turrets	3	9.45	4.78	48	42	(72)	14	11	73	14	-04	33	44	33	30	25	16	40	15	30	36	34	40	39	46
Teach. techniques	4	6.87	2.60	30	45	14	(28)	40	57	14	13	25	24	34	32	21	10	37	20	30	27	22	33	28	39
Technical aids and procedure	5	4.38	2.14	29	38	11	40	(23)	50	13	05	26	26	33	31	20	-01	35	18	28	29	23	33	31	39
Total score	6	35.29	10.66	80	79	73	57	50	(77)	22	08	43	54	53	45	35	01	57	30	50	57	44	62	52	63
Teaching:																									
Basic gun teaching	7	2.87	.56	17	20	14	14	13	22	(a)	28	20	15	18	15	10	13	24	06	13	08	06	12	15	21
Practice teaching	8	5.31	1.72	01	13	-04	13	05	08	28	(a)	11	-02	20	10	01	22	19	01	13	07	00	08	01	13
CSFG qualifying Book I:																									
Vocabulary	9	9.64	3.64	34	41	33	25	26	43	20	11	(66)	48	47	46	32	11	77	23	39	30	18	42	48	67
Mechanical principles	10	6.75	2.19	47	45	44	24	26	54	15	-02	48	(55)	40	41	37	03	65	27	43	45	39	53	59	69
Mathematics	11	11.18	2.97	39	54	33	34	33	53	18	20	47	40	(66)	44	34	09	71	19	47	36	30	45	44	65
Reading comprehension	12	4.96	2.10	34	39	30	32	31	45	15	10	46	41	44	(48)	30	16	67	15	36	32	35	41	45	61
Surface development	13	12.81	2.28	30	31	25	21	20	35	10	01	32	37	34	30	(82)	03	55	21	39	31	30	41	40	56
Teaching aptitude	14	24.99	4.35	03	-02	16	10	-01	01	13	22	11	03	09	16	03	(61)	47	01	04	06	04	05	09	27
Total aptitude Book I	15	70.33	9.25	46	53	40	37	33	57	24	19	77	65	71	67	55	47	(82)	27	52	45	42	56	61	88
CSFG Qualifying Book II:																									
Aircraft recognition	16	3.90	2.66	26	30	16	20	18	30	06	01	23	27	19	16	21	01	27	(50)	40	33	29	60	27	47
Sighting	17	11.11	3.35	42	54	30	30	28	50	13	13	39	43	47	36	39	04	52	40	(54)	50	39	76	14	70
Weapons	18	16.14	4.21	61	47	36	27	29	57	08	07	30	45	36	32	31	06	45	33	50	(65)	56	84	42	70
Turrets	19	9.60	3.76	42	37	34	22	23	44	06	00	18	39	30	35	30	04	42	29	39	56	(54)	77	46	67
Total achievements, Book II	20	45.76	9.81	59	56	40	33	33	62	12	08	42	53	45	41	41	05	56	60	76	84	77	(72)	54	86
CSFG Book III:																									
Mechanical comprehension	21	17.69	5.12	44	46	39	28	31	52	15	01	48	59	44	45	40	09	61	27	44	42	46	54	(84)	78
Grand total	22	133.79	17.22	60	62	46	39	39	63	21	13	67	69	65	61	56	27	88	47	70	70	67	86	78	(80)

[1] Decimal points omitted for correlations. Coefficients corrected for restricted range. See footnote 15.
[a] Reliability coefficients could not be computed.

In an attempt to isolate factors which might be indicative of success as an instructor in the flexible gunnery program and as a preliminary step in the revision of the Instructors Qualifying Examination, a factor analysis was computed, using as its matrix the correlation coefficients shown in table 12.17. Table 12.22 shows the results of this study. Interpretations of these results may be summarized as follows:

1. The validity coefficients obtained for every test were generally in good agreement with the predicted coefficients based on the factor loadings.
2. The part tests of the examination accounted for some of the factors isolated, but large, unknown factors remained undetermined.
3. There were further factors in the criteria which were not common to the examination battery and hence not predicted by it.

TABLE 12.18.—*F–ratios between the scores of instructors at five basic gunnery schools compared by schools, by departments of instruction, and attendance at CIS, using aptitude scores on the Instructors Qualifying Examination; separate F–ratios are presented for differences on Part I-V; and Part VI (August-September 1945)*

Source of variation	Sum of squares	*df*	Estimate of variance	F–ratio
Scores on parts I-V:				
Between cells	69,705.276	71		
Within cells (error)	63,274.826	1,540	41.088	
Between schools	6,216.629	4	1554.157	[1] 37.82
Between departments	2,414.187	7	344.884	[1] 8.39
Between CIS and non-CIS	49.173	1	49.173	1.20
Total	132,980.102	1,611		
Scores on part VI:				
Between cells	1,763.421	71		
Within cells (error)	35,122.467	1,540	22.807	
Between schools	341.119	4	85.298	[1] 3.74
Between departments	533.536	7	76.219	[1] 3.34
Between CIS and non-CIS	13.896	1	13.890	[2] .61
Total	36,885.888	1,611		

[1] With the appropriate degrees of freedom, a value as large as this would be expected less than one time in 100 by chance alone.
[2] With the appropriate degrees of freedom a difference as large as this would be expected to occur more than five times in 100 by chance alone.

Any attempt to assign labels to factors is at best a speculative process. Factors three and four seem to defy interpretation. Factor one seems to be heavily loaded with the weapons, sighting, and turret tests, and fairly high on mechanical principles, aircraft recognition, and mathematics. This factor may be termed a mechanical-gunnery knowledge factor. Factor two seems to be high in vocabulary and reading comprehension, mechanical principles, mathematics, and the Santa Ana mechanical principles test. This factor might be called verbal-mechanical comprehension.[20]

[20] This study was done by Capt. Lawrence M. Stolurow and Sgt Milton C. Lieberman.

In order to maximize the predictive efficiency of the Instructors Qualifying Examination in the form presented, beta weights for the eight subtests found most promising on the basis of a multiple correlation study were computed. Table 12.23 shows these beta weights as recommended for use.

TABLE 12.19.—*F-ratios between the scores of instructors at five basic gunnery schools compared by departments, by schools, and by turret studied using achievement scores on the Instructors Qualifying Examination: Separate F-ratios are reported for differences computed on the scores of each part and the total (August-September 1944)*

Source of variation	Sum of squares	df	Estimate of variance	F-ratio
Part I (aircraft recognition):				
Between turrets	267.849	5	53.579	[1] 6.000
Between departments	1,037.762	7	148.252	[1] 16.602
Between schools	972.327	4	243.082	[1] 27.220
Between cells	3,474.427	122		
Within cells	13,476.651	1,498	8.930	
Total	16,851.078	1,620		
Part II (sighting):				
Between turrets	477.349	5	95.470	[1] 5.440
Between departments	2,630.855	7	375.836	[1] 21.414
Between schools	1,610.495	4	402.624	[1] 22.940
Between cells	8,493.171	122	17.551	
Within cells	26,291.235	1,498		
Total	34,784.406	1,620		
Part III (weapons):				
Between turrets	1,039.548	5	207.910	[1] 10.146
Between departments	9,568.016	7	1,366.859	[1] 66.702
Between schools	2,543.906	4	635.977	[1] 31.035
Between cells	16,559.321	122		
Within cells	30,697.486	1,498	20.492	
Total	47,256.807	1,620		
Part IV (turrets):				
Between turrets	2,960.809	4	740.201	[1] 63.001
Between departments	3,381.553	7	483.079	[1] 41.117
Between schools	1,936.884	4	484.221	[1] 41.21
Between cells	9,266.069	117	79.197	
Within cells	17,341.619	1,476	11.749	
Total	26,607.688	1,593		
Between turrets	10,831.758	4	2,707.940	[1] 22.384
Between departments	87,312.895	7	12,473.271	[1] 103.107
Between schools	17,551.027	4	4,387.757	[1] 36.270
Between cells	58,708.155	117		
Within cells	178,557.587	1,476	120.974	
Total	237,265.742	1,593		

[1] Differences found indicate that with the appropriate degrees of freedom they would be likely to occur by chance less than 1 time in 100.

Use in the reclassification of instructors.—In accordance with a directive issued by Headquarters, Army Air Forces, a number of boards were established to examine instructors who had attended the Instructors School for reclassification to Specification Serial No. 938, a classification ordinarily given only to graduates

TABLE 12.20.—*F-ratios between the scores of students at five basic gunnery schools compared by school attended: Separate F-ratios are presented for differences computed on two scores; parts I through V; and VI (August-September 1944)*

Source of variation	Sum of squares	df	Estimate of variance	F-ratio
Scores on subtests I-V:				
Between turrets	7,313.821	4	1,828.455	[1] 20.511
Within schools (error)	112,408.883	1,261	89.143	
Total	119,722.704	1,265		
Scores on subtest VI:				
Between turrets	665.413	4	166.353	
Within schools (error)	28,745.686	1,261	22.796	[1] 7.297
Total	29,441.099	1,265		

[1] With the appropriate degrees of freedom, a value as large as this would be expected less than one time in 100 by chance alone.

of the Instructors School.[21] The responsibilities of the Research Division in this program were to set the standards to be met by the candidates for reclassification, to develop the procedures and instruments to be used, and to indoctrinate members of the boards.[22]

The standards with respect to the examination, set on the basis of minimum scores of Instructors School graduates, were a score of 67 on Booklet I and 62 on Booklet II. A minimum rating of three on either the Gunnery Instructors Rating Scale or the Phase Check Rating Scale was required for instructors and phase checkers respectively in order to correspond to graduation standards. In addition, all candidates had to have a satisfactory rating based on the interview with one of the officers of the board. In processing, the standards were applied at each phase so that only those candidates who passed the examinations were rated, and only those passing the rating situation were interviewed. This procedure was used to maximize the efficiency with which the ratings and interviews were conducted.

A 2-day program was established for the indoctrination of the board personnel. The program included both lectures and practice sessions in the use of the tests, the interview forms, and the rating scales. A principal emphasis in the practice periods on the rating scales was placed on the standardization of interpretation of the ratings among the board members, since all members had had experience in their use. All possible combinations of members were used and discussions were held among them to work out differences in an attempt to develop well-matched teams.

[21] TWX AFPMP-12 2779 as quoted in Ltr., Hq., AAFTRC dated 5 Oct. 1944 Subj: Examining Board for Reclassification of Instructors.

[22] The personnel responsible for this project were Capt. Lawrence M. Stolurow and Lt. Gerald R. Pascal.

All members were given a copy of a "Manual For Instructor Reclassification Board," prepared by the Research Division. This manual included a detailed description of the test, the forms, and the procedures to be used. Finally, all board members cooperated in testing the candidates at Laredo.

TABLE 12.21.—*F-ratios between the scores on instructor qualifying examination (achievement) of students at three basic gunnery schools computed by schools attended, and turrets studied: Separate F-ratios are presented for each part and for total score (August-September 1944)*[1]

Source of variation	Sum of squares	df	Estimate of variance	F-ratio
Part II (sighting):				
Between turrets	836.361	5	167.272	12.897 **
Between schools	169.734	2	84.867	6.543 **
Between cells	963.885	10		
Within cells (error)	9,792.437	755	12.970	
Total	10,756.322	765		
Part III (weapons):				
Between turrets	1,599.833	5	319.967	10.071 *
Between schools	24.004	2	12.002	.378
Between cells	1,773.170	10	31.772	
Within cells (error)	23,987.639	755	31.772	
Total	25,760.650	765		
Part IV (turrets):				
Between turrets	3,053.076	8	1,017.692	65.618 **
Between schools	2,337.020	2	1,168.510	75.344 **
Between cells	3,421.474	7		
Within cells (error)	10,112.082	652	15.509	
Total	13,533.556	659		
Total test:				
Between turrets	4,592.886	3	1,530.962	12.261 **
Between schools	2,703.636	2	1,351.818	10.826 **
Between cells	5,985.931	7		
Within cells (error)	81,288.743	651	124.868	
Total	87,274.724	658		

[1] The number of times in 100 that an F-Ratio as large as each one obtained would be expected to arise by chance is indicated by the following system:
No asterisk: More than 5 times in 100.
*: Between 1 and 5 times in 100.
** Less than 1 time in 100.

The immediate result of this undertaking was the increase in the total number of men who were qualified as Flexible Gunnery Instructors with the Specification Serial Number of 938. Moreover, during the course of the examinations, data were obtained which serve as validation of the selection procedures which have been outlined in this chapter and the training procedures which will be discussed in the following section. To establish the validity of the examination used in the reclassification proceedings, the boards gave the Instructors Qualifying Examination to a number of men who were graduates of the Instructors School, along with men who had not been through the school. To equalize somewhat the factor of recency of instruction in gunnery subject matter, the non-graduates (non-938's) were given a brief

TABLE 12.22.—*Factor loadings, communalities, reliabilities, and predicted and obtained validity with two criteria by the centroid method using the CSFG Qualifying Examination Battery (N=675, Instructors School, July 1945)*

	Factor loadings after 9 rotations				h^2	r_H	Predicted validity IC-FC-C	Obtained validity IC-FC-C	Predicted validity basic teaching	Obtained validity basic teaching
	1	2	3	4						
Criterion:										
IC-FC-C total	0.663	0.338	−0.085	−0.134	0.578	0.768			0.202	0.218
Basic gunnery teaching	.115	.291	−.123	−.132	.130	(1)	.202	.218		
GSFG Qualifying Examination, Booklet I:										
Vocabulary	.346	.624	−.119	.141	.543	.664	.431	.433	.217	.200
Mechanical principles	.568	.410	.18[illegible]	.192	.547	.546	.478	.535	.142	.146
Mathematics	.490	.444	−.217	−.102	.495	.656	.507	.528	.226	.184
Reading comprehension	.400	.510	.079	.112	.439	.478	.446	.447	.109	.146
Surface development	.456	.255	.000	.188	.292	.816	.370	.348	.108	.095
Teaching aptitude	.000	.250	.082	−.175	.097	.614	.102	.012	.088	.132
CSFG Qualifying Examination, Booklet II:										
Aircraft recognition	.501	.000	−.074	.190	.293	.503	.313	.295	.042	.060
Sighting	.690	.170	−.225	.101	.566	.537	.521	.502	.143	.126
Weapons	.755	.040	.093	−.161	.608	.648	.528	.570	.108	.084
Turrets	.687	.048	.293	−.161	.555	.542	.452	.443	.073	.061
Book III: Mechanical Operation (DS201A)	.562	.467	.206	.157	.601	.640	.492	.516	.154	.153

[1] Reliability unknown.

TABLE 12.23.—*Multiple correlation coefficients and beta weights of the original 10 parts of the Instructors Qualifying Examination Battery and for 8 of the most valid parts, Instructors School (N=675, July 1945)*

Parts	8 parts criteria[1] 1	2	3
Instructors Qualifying Examination Booklet I:			
Vocabulary	0.007	0.110	0.025
Mechanical principles	.182	.050	.144
Mathematics	.216	.096	.188
Reading comprehension	.110	.021	0.18
Surface development	------	------	------
Teaching aptitude	—.061	.107	.199
Instructors Qualifying Examination Booklet II:			
Aircraft Recognition	------	------	------
Sighting	.097	.021	.093
Weapons	.269	.023	.042
Turrets	.071	—.014	—.080
Multiple R	.723	.253	.324

[1] Criteria:
1—Instructors Course, Final Comprehensive Examination, Form O.
2—Basic Gunnery Teaching.
3—Practive Teaching.

refresher course, and only men who had been graduates from the Instructors School at least 6 months previously were included in the graduate group (938's). The results are summarized in table 12.24. They show quite clearly the superiority of the men who had been selected for and trained at the Instructors School, both in terms of percent passing the examination and percent having an Army General Classification Test score above 115.

TABLE 12.24.—*Comparison of instructors in training air forces who were graduates of the Instructors School (SSN 938) and those who had not attended the school: Percent passing Instructors Qualifying Examination and percent having Army General Classification Test scores below 115 (four training air force stations, first quarter, 1945)*

Air Force Station	Number examined		Percent passing		Percent having AGCT below 115	
	938's	Non-938's	938's	Non-938's	938's	Non-938's
Greenville	52	100	67	18	21	48
Rapid City	82	22	40	9	15	50
Gulfport	24	122	62	7	4	57
Tonopah	21	6	76	0	10	67
Total	179	250	55	12	15	53

Summary

This chapter has presented an account of instructor selection in the flexible gunnery program. It began by presenting, briefly, the early status of instructor selection, showing the heterogeneity of the population of instructors in terms of skills and ability. This early status pointed to the need for an objective means of selecting instructors. To meet this need the Instructors Qualify-

ing Examination was constructed. Several exploratory or incomplete attempts at test construction are described. The final test battery is presented, giving illustrative items, reliability, and validity coefficients. The practical use of Instructors Qualifying Examination is documented, showing its use in instructor selection by the Personnel Distribution Command and by the Flexible Gunnery Reclassification Boards, and its use as a research instrument.

The task of constructing an aptitude test which would predict teaching ability in the flexible gunnery program was beset with all the ills attendant upon any attempt to predict teaching ability. Many intangibles contributed to this ability. Some of those were measured in the Instructors School by means of a rating scale. To demonstrate the validity of the qualifying examination it was necessary to select items which would correlate with these ratings; but this was complicated by the fact that the rating scale was variously used, sometimes with measurable reliability and in other instances with unknown reliability. Thus the final selection of items to measure teaching aptitude was a compromise between the power of items to predict success on the rating scale, and *a priori* judgments of factors making for over-all success as an instructor. Briefly expressed, these factors were construed to be intelligence, gunnery knowledge, and facets of personality pertinent to instructing. Test items attempted to cover these areas insofar as it was possible with a printed test. Scores on the final battery of the Instructors Qualifying Examination showed a better than chance relationship with the criteria of success in the Instructors School, and the examination was accepted as the principal basis of instructor selection for the flexible gunnery program.

THE TRAINING OF INSTRUCTORS

Contributions to the training of instructors were made in two main ways: first, by services rendered to the Instructors School in order to increase its effectiveness in training gunnery instructors; and second, by the preparation of manuals nad bulletins for use by instructors already on the job to increase their effectiveness in certain phases of teaching. Among the specific jobs accomplished were the development of achievement tests for use in Instructors School courses; the exploration of the problems involved in utilizing returned from combat gunners as instructors; the preparation of manuals on specific instructional jobs; and cooperation with other agencies in the development of manuals for intercommunication instruction and in the preparation of three films for use in instructor training. In addition to these

relatively identifiable services, assistance was rendered to the Instructors School in the solution of various problems on an informal basis in the course of day-to-day relationships. Although individual suggestions usually had relatively minor consequences, their cumulative effect was presumably appreciable.

The Development of Achievement Tests

The Research Division constructed achievement tests for the various Instructors School courses, and the Instructors Final Comprehensive Examination. In most respects, the procedure followed in this work was similar to that used in the development and revision of the Gunnery Final Examination as described in chapter 7. Close relationships were maintained with instructors and supervisors in the various courses in the preparation of items and in verifying the technical adequacy of items.

The examination developed for the Teaching Methods course differed somewhat from conventional achievement tests in that it required the student to judge which of seven teaching methods was most appropriate to a variety of concrete teaching situations; and to judge which of six principles considered important in formulating lesson plans was involved in each of a number of concrete illustrations of teacher activity.[23] This test was found to have a reliability of 0.63 for 153 students in class 44-1, by means of Kuder-Richardson Formula No. 21. For this class, the mean score was 13.8 and the standard deviation 5.1. This test was used in the Instructors Course as a course examination until the end of the war.

Survey of Combat Returnee Instructors

In the spring of 1944, a survey of gunnery schools with respect to their experience in the use of returned from combat gunners as instructors was conducted.[24] Reports that some men assigned for duty were not properly qualified to serve as instructors, and that some were too restless to teach effectively pointed up the need for this study, particularly since a large influx of returned from combat gunners was anticipated. The survey included correspondence with each of the gunnery schools, and a visit to Harlingen, which had reported relatively good results with this group. The information obtained emphasized the need for careful screening of returnees before assignment as instructors, the need for systematic effort on the part of supervisory personnel to seek to arouse interst in becoming a good instructor among gunners assigned to this job; and a definite need for refresher

[23] This test was devised by Lt. Joseph Wepman.

[24] This study was done by Capt. Wilbur S. Gregory.

TABLE 12.25.—*Proficiency on Gunnery Final Examination (Form GFC) of combat returnees tested before refresher training and of combat returnees and basic gunnery students at completion of course (December 1943)*

Group	N	GFC score		Diff. returnees v. basic gunners	CR_{diff}
		M	SD		
Combat returnees before retraining (Buckingham)	62	87.63	24.64	35.73	[1] 25.82
Combat returnees after retraining (Buckingham)	31	123.36	11.90	3.63	[2] 2.25
Basic gunnery students, end of course (Las Vegas)	530	126.99	8.52		

[1] A critical ratio of this size would be expected to arise by chance less than 1 time in 1,000.
[2] A critical ratio of this size would be expected to arise by chance less than 5 times in 100.

training in basic gunnery and in teaching methods for returnees before they entered upon instructional duties. Table 12.25 provides evidence regarding the gunnery knowledge as shown on Gunnery Final Examination performance by returnees and by basic gunnery students. It was noted that the returnees tested prior to refresher training obtained much lower scores than did basic gunnery students at the completion of training; and that returnees tested at the end of refresher training did slightly less well than the basic gunners. A bulletin summarizing those results and offering concrete suggestions for improving the motivation of returnee instructors and for reducing the effect of combat fatigue symptoms upon instructor effectiveness was distributed to the gunnery schools. A booklet, *Your Next Mission*, designed to aid the returnees in adjusting to duty in the United States and to arouse as much interest as possible in instructing, was prepared and distributed to returning gunners. In addition to these efforts to improve proficiency of returnees assigned as instructors, steps were taken which led to more stringent application of standards for selecting instructors from the returnee group.

Cooperation With Other Agencies in Developing Instructor Aids

Members of the Research Division collaborated with personnel of the National Defense Research Committee Voice Communication Laboratory in Waco, Tex., in collating research findings on the use of aircraft intercommunication equipment, in determining the implications of these findings for gunnery, and in preparing manuals for instructors teaching the use of this equipment. Familiarity with psychological concepts of speech, with effective training methods, and with gunnery instructors facilitated the

preparation of manuals designed to increase the effectiveness of interphone instructors.[25]

In cooperation with the AAF First Motion Picture Unit, Culver City, Calif., members of the Research Division aided in preparing three training films designed primarily to aid in instructor training.[26] These division personnel aided in the preparation of 10 other training films designed for use by instructors in teaching various phases of gunnery.

Other Services in Instructor Training

Among a variety of specific recommendations made and jobs done during the course of more than 2 years of close association with the Instructors School, a few of the more important may well be noted. As early as April of 1943, the director of the Psychological Research Detachment (Gunnery) suggested in a research note the great desirability of providing adequate opportunities for practice teaching in the training of instructors, a proposal which was adopted. Again, aid was given to the Instructors School in selecting a well qualified educational consultant to prepare the teaching methods manual for gunnery instructors.[27] Research Division personnel prepared manuals on the proper administration of phase checks, on the proper use of student rating scales, on the scoring of gun camera film and on the most effective means of administering and interpreting objective tests, in an effort to aid instructors in these aspects of their job.

Summary

The training of instructors was an aspect of improving gunnery which was dealt with informally and through the providing of specific services rather than through a program of research. The services included the development of achievement tests, the preparation of manuals, and aid in dealing with the effective utilization of returned from combat gunners as instructors.

SUMMARY

Proficiency in a gunnery instructor is ultimately reflected in the proficiency of his students. Research in the selection of flexible gunnery instructors took a more limited view of the problem, since it attempted to identify and measure characteristics in an

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[25] This work was done by Lt. Joseph Wepman, Lt. George J Wischmer, Cpl. James H. Neely, and Lt. Joseph L. Joyner.

[26] Major Robert Bragarnick and Capt. Morgan A. Greenwood were largely responsible for the splendid series of training films developed in the flexible gunnery program.

[27] Teaching Methods Manual for Flexible Gunnery Instructors, Air Forces Manual No. 16, prepared by the Instructors School, Flexible Gunnery, Laredo, and the Department of Educational Research, Ohio State University, Columbus, Ohio, May 1944.

instructor which could reasonably be assumed to be significant qualities of good teachers. The four main aspects chosen were intelligence, gunnery knowledge, personal adjustment and teaching proficiency. Of these, intelligence and gunnery knowledge were considered to be measurable by existing tests. A group judged to be high in needed personal qualities, namely the staff of the Instructors School, was used as a basis for validating tests involving personal adjustment. Teaching proficiency was measured by means of a rating scale, which proved to yield satisfactory reliabilities among raters evaluating the same performance.

Initial contributions to the selection of instructors involved the screening of instructors already assigned to ensure that substantially all instructors met minimum standards in AGCT score and in gunnery knowledge. Instructors were expected to have an AGCT score of 120 or above and a knowledge of gunnery, as demonstrated on objective tests, which placed them in the highest 25 percent of gunnery graduates.

The need for a test specifically designed to aid in the selection of instructors was recognized. The Instructors Qualifying Examination was constructed to provide such an instrument. This test included items relating to learning ability, to gunnery knowledge, to personal qualities, and to attitudes on instructing. Validation studies of this test against success in the final comprehensive examination and against teaching ratings were carried out. The relationship obtained showed satisfactory prediction of the objective test performance and markedly poorer prediction of ratings of teaching proficiency. For both criteria, however, correlations too large to attribute to sampling error were obtained.

The Instructors Qualifying Examination was used in surveying the level of qualifications of gunnery instructors in the various schools and in the various departments, and also in a reclassification program in which proficient instructors were given the Military Occupational Specialty of gunnery instructor without attending the Instructors School. A factor analysis of this test was carried out in order to gain a clearer understanding of its characteristics.

With respect to the training of instructors, activities of the Research Division centered around constructing achievement tests for the Instructors School, preparing various manuals for use by instructors, and providing information useful in the solution of various problems arising in the training of instructors.

CHAPTER THIRTEEN

The Selection and Training of Gunnery Officers

Lt. William B. Schrader, Lt. Gerald R. Pascal, Capt. John A. Valentine

THE NATURE OF GUNNERY OFFICER PROFICIENCY

Introduction

Early in 1944, there developed a strong demand for officers qualified to serve as gunnery specialists in combat organizations. These gunnery specialists were needed at the squadron, the group, the wing, the division, and the command levels. Thy were particularly in demand in the 8th Air Force, though the need for officers to supervise gunnery in combat was generally recognized. In the face of this need, the establishment of a school for the training of gunnery officers and the formulation of standards for the selection of students for this school presented problems which had to be dealt with quickly. Attention was first focussed on the nature of the gunnery officer's job and on the characteristics of the effective gunnery officer.

A number of gunnery officers were already functioning in the 8th Air Force. These gunnery officers had not been selected or trained in accordance with a formal program, but had acquired their duties as a means of dealing with gunnery problems in their units. As a result, their duties varied markedly with the qualifications and limitations of the individual officer and with the problems of the specific unit in which he was located. In order to obtain an adequate picture of the gunnery officer's job, it was necessary to survey systematically the duties of a number of these officers who were considered to be doing their job well.

To accomplish this systematic survey of the duties of the gunnery officer, it was decided to send an officer to the 8th Air Force, where the role of the gunnery officer had been best defined through experience. But, as was so often the case in gunnery training, action could not await a thorough laying of groundwork. Plans

for the school had to go forward immediately, on the best available judgment of what the gunnery officers might be expected to do. Therefore an "armchair" job analysis was drawn up, a tentative curriculum was blocked out, and certain tentative qualifications for entrance into the school were formulated. Then an officer who had been actively engaged in this preliminary, deductive analysis was sent to the 8th Air Force to verify and supplement the analysis and to obtain materials which would be useful in rounding out the curriculum.

The Gunnery Officer's Job

Stated in terms of its purpose, the gunnery officer's job was to bring about and maintain maximum combat effectiveness of gunners assigned to his unit. It was assumed that he needed to know what factors contributed to the effectiveness of gunners in combat, to be able to detect areas in which improvement in proficiency was most needed, and to be able to take the proper corrective action. He needed, in addition, to adapt his activities continuously in response to changing conditions of combat in his theater.

In order to find out specifically what gunnery officers were doing to improve gunnery proficiency, and to secure a picture of the tasks they were expected to perform in their units, the study of 8th Air Force gunnery officers, mentioned above, was carried out.[1] This survey involved locating 25 gunnery officers who were judged to be proficient in their duties, interviewing them systematically, studying and analysing their conception of their job, and observing them at work. Further perspective on the gunnery officer's job was obtained by studying the selection and training program carried out by the Royal Air Force for gunnery leaders, their counterpart to our gunnery officer.

In the systematic interviews with gunnery officers, an effort was made to get an evaluation of the importance of various kinds of knowledge and ability and an estimate of the frequency with which they were needed. Specific types of knowledge and ability considered were:

Knowledge of flexible gunnery.
Knowledge of training principles as applied to gunnery training.
Knowledge of maintenance of gunnery equipment.
Ability to check on maintenance of gunnery equipment.
Knowledge of the practical use of gun armament.
Knowledge of briefing and of post-operational interrogation.
Knowledge of administrative and disciplinary procedures.
Knowledge of factors influencing morale.
Knowledge of the care and maintenance of the gunner.

In addition, gunnery officers were asked to judge the minimum

[1] This study was made by Maj. Roger W. Russell in January and February, 1944.

acceptable level in each of 20 characteristics which had been identified as relevant to aviation cadet selection and classification. The gunnery officer expressed this judgment by indicating, on a 9-point scale, the minimum degree of each characteristic requisite for effectiveness on the job. Comments and suggestions were obtained from the officers interviewed in order to supplement and clarify the information obtained through the interviews and ratings. The description of the gunnery officer's job thus obtained was considered in the formulation of the selection and training program of the Combat Gunnery Officers Course, which began operation in May, 1944. The discussion of the gunnery officer presented below is a summary of the findings of this study.

The gunery officer as teacher.—The most important task of the gunnery officer, according to the gunnery officers doing the job, was to organize and carry on a training program to increase the proficiency of the gunners in his organization. Skill in effective presentation of materials, ability to recognize individual differences and to deal with them intelligently, and ingenuity in the development and use of practical demonstrations were stressed as essential to good results.

In connection with his responsibility for improving gunnery proficiency, the gunnery officer was called upon to plan and carry out a training program for his unit in accordance with sound teaching principles, to select and train gunners to act as gunnery instructors, to supervise any trained gunnery instructors assigned to his unit, to do a considerable amount of teaching, to procure or improvise adequate training facilities and training aids, and to keep up to date on recent developments in gunnery and in gunnery training methods. Recognition of the crucial importance of the task of continuing the training of gunners during their combat tour was essential to an understanding of the gunnery officer's job. Gunnery officers in the 8th Air Force consistently emphasized the importance of this function, and the necessity for experience in teaching as a part of gunnery officer training.

The gunnery officer as gunner.—A majority of gunnery officers interviewed agreed that the gunnery officer should fly periodically on operational missions, in order to maintain prestige, to gain a better understanding of the problems faced by the gunners, and to increase his insight into practical aspects of gunnery and tactics in aerial combat. This, in turn, meant that the gunnery officer had to possess all gunnery skills necessary to permit him to do his full share in protecting his bomber on these missions. In particular, it meant that he had to maintain a high standard of marksmanship, of courage, of crewmanship, and of skill in caring for his guns and personal equipment.

The gunnery officer as technical expert.—It was found that certain kinds of technical experiences were particularly needed by the gunnery officer. To answer gunners' questions meaningfully, the gunnery officer needed a thorough grounding in the theory of sighting and in the functioning of machine guns and turrets. To provide adequate supervision of maintenance, he needed experience in preflight and postflight checks on the maintenance job being done by the various specialists. A number of gunnery officers indicated that the gunnery officer needed a detailed knowledge of turret maintenance. He needed to be conversant with all important features of gunnery equipment on the type of aircraft used by his unit. Specifically, he had to know the machine gun well enough to be able to deal intelligently with special problems which arose, for example, in relation to proper lubrication, to the timing of the solenoids, and to the effects of temperature on the operation of the gun. Finally, although there was not unanimous agreement on this, the gunnery officer's job frequently involved serving as a source of information on tactical problems as they affected gunnery, including such matters as evasive action, search procedures, characteristics and tactics of enemy fighters, and fields of fire and armament characteristics of the type of the bomber flown by his own units.

The gunnery officer as leader.—In addition to his specialized duties, the gunnery officer could and did function as a leader. In this phase of his responsibility, one of his biggest jobs was that of maintaining the morale of the gunners in his unit. This involved obtaining recognition of the importance of gunnery by all members of the unit, providing the best possible conditions for gunners in carrying out their duties, and solving or alleviating, wherever possible, problems or "gripes" of his gunners. Basically, he had to gain the confidence of all personnel in his unit in his ability to aid in solving problems involving gunners or gunnery. This required not only energy and knowledge of gunnery but also an understanding of administrative and disciplinary procedures.

Among the various relationships of the gunnery officer to other staff members, three were considered of special importance. First, he needed a complete understanding with his commanding officer regarding his functions and their contribution to the overall effectiveness of the unit. Second, he needed to maintain close liaison with the intelligence officer both in briefing and in interrogation. Knowledge of those procedures was useful in enabling him to act as an intermediary between the intelligence officer and the gunners by clarifying the intelligence officer's remarks during briefing and by clarifying technical points reported by the gun-

ners during interrogation. Third, the gunnery officer was able to provide an additional valuable service by keeping the flight surgeon informed on signs of mental or physical fatigue observed in his contacts with gunners, and by using discretion in referring to the flight surgeon gunners in need of special attention.

In addition to maintaining close liaison with the intelligence officer, the more effective gunnery officers were skilled in conducting "gunners critiques." Here the officer had to be able to find out what gunners had learned on recent missions, to answer their questions, to discover causes of personnel failures, and to develop a situation conducive to building up a feeling of cooperation among the crew members.

The gunnery officer as a person.—The 25 gunnery officers interviewed in this study were systematically asked to designate what they considered to be the minimum acceptable standards for a gunnery officer in each of 20 characteristics. The characteristics were those which had been previously identified as important in the selection and classification of aviation cadets.[2] The results of these ratings are in accord with the type of duties described above. The 5 characteristics in which the gunnery officer needed especially to excel were leadership, dependability, motivation, emotional control, and judgment. Next came mechanical comprehension, memory, and speed of decision and reaction. High standards were set by the rating officers in all 20 of the traits. The mean ratings on each trait, based on a scale of 1 to 9, are presented in table 13.1.

The official job description.—Of the variety of duties which gunnery officers were expected to perform, the revised job description of the Flexible Gunnery Officer (Specification Serial Number 2554), as specified by Headquarters, Army Air Forces, may serve as a summary:[3]

Directs and supervises, in the air and on the ground, flexible gunnery training and operations within the organization to which he is assigned. Insures that gunners are thoroughly familiar with the appropriate gunnery equipment, accessories, and the latest flexible gunnery tactics and techniques. Insures that all gunnery equipment is properly inspected at regular intervals. Directs the instruction of gunners in crew coordination. Supervises the accomplishment of the duties of gunners prior to combat missions. Makes periodic flight checks with gunners, reporting to the operations officer all gunners not suitable for combat operations.

Assists in planning tactical and training operations. Maintains liaison with flexible gunnery officers of other echelons and with operations officers and staff officers. Provides guners with the necessary training in specialties other than their own to complete or augment their combat training. Coordinates with maintenance and armament officers in making necessary reports on gunnery equipment.

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[2] The procedure for this aspect of the study was formulated by Col. John C. Flanagan.

[3] Inclosure to AAF Letter 35-186, Revision of the Military Occupational Specialty Aerial Gunnery Instructor (SSN 2554), dated 21 February 1945.

TABLE 13.1.—*Minimum acceptable standards for gunnery officers on each of 20 characteristics as judged by 25 proficient gunnery officers in the 8th Air Force (January-February 1944)*

Name of characteristic	Mean rating[1]	SD of ratings
Judgment	6.56	1.77
Mechanical comprehension	6.40	1.67
Arithmetic calculations	5.52	1.51
Arithmetic reasoning	5.48	1.58
Mathematics	5.20	1.77
Reading comprehension	6.28	1.76
Memory	6.40	1.95
Dial and table reading	5.00	1.62
Vizualization of the flight course	5.68	1.71
Estimation of speed and distance	5.72	1.80
Orientation and observation	5.12	1.72
Division of attention	6.16	1.67
Speed of decision and reaction	6.40	1.72
Serial reaction time	5.84	1.65
Coordination	5.56	1.57
Finger dexterity	4.88	1.59
Emotional control	6.68	2.00
Motivation	6.80	1.87
Dependability	7.04	1.94
Leadership	7.32	1.91

[1] Ratings based on a 9-point scale: 9 being the highest rating and 5 being the assumed rating of the average aviation cadet.

Maintains a continued analysis of flexible gunnery performance to determine the most suitable gunnery procedures for use in the area in which operations are conducted, submitting recommendations relative to improvement in flexible gunery equipment, training methods, techniques and procedures.

Completion of basic gunery school course, or equivalent experience, and successful completion of the prescribed course of instruction for flexible gunnery officers at an AAF special service school is required.

The Measurement of Proficiency of the Gunnery Officer

The ultimate criterion of the effectiveness of the gunnery officer was the performance of the gunners of his unit in bringing down enemy planes. In practice, however, this criterion suffered both from inaccessibility of the necessary data and from the wide variations in conditions among the various units to which gunnery officers were assigned.

An evaluation of each gunnery officer in terms of his effectiveness as a teacher, as a leader, as a gunner, as a technical expert, and as a person was the next choice as a criterion. It so happened, however, that of these areas, only his skill and knowledge in gunnery could be adapted to objective measurement. Ratings on personal qualities, or on skill in teaching or in administering an instructional program, which are difficult to evaluate at best, were further complicated in this situation by the fact that gunnery officers worked to a large extent individually. Ratings of squadron gunnery officers might have been done by gunnery officers attached to higher echelon in the same command, but this was not done. The wide geographical dispersal of gunnery officers constituted the primary practical obstacle to the execution of such studies.

In the absence of data which would permit an adequate evaluation of gunnery officers functioning in their job, the most appropriate means of evaluating proficiency was performance in the Combat Gunnery Officers Course. The usefulness of this criterion was enhanced by the fact that the curriculum of this course was closely related to the description of the gunnery officer's job outlined in the first part of this chapter. Since the curriculum followed the job description closely, and since an effort was made to evaluate the promise of each student as a gunnery officer in terms of his performance in various aspects of his training, the operating program of the school offered useful information regarding the relative excellence of the students in the various aspects of the gunnery officer's job.

Examination of specific information collected in the Combat Gunnery Officers Course on each student for administrative purposes revealed the following possibilities as indexes of proficiency:

(1) Weekly character ratings given to each student by the commandant of students, flight commanders, and instructors;
(2) Course grades in the several courses;
(3) Final comprehensive examination scores;
(4) Graduation *versus* elimination from the course.

Of these, reliability data were available on the final comprehensive examination only. An estimate of 0.69 for this reliability was obtained for scores of 54 students in classes 44–4 and 44–6 by use of Kuder-Richardson Formula No. 20.[4] Study of the various criteria indicated that graduation-elimination appeared to be most promising, since it represented an evaluation of the student as a potential gunnery officer, and since it also reflected course grades, final examination scores, and character ratings. Moreover, elimination represented an important administrative action, since the school was necessarily judged by the kind of graduates it sent to the combat squadrons.

One study of the reasons for elimination was carried out on 32 students eliminated from classes 44–1, 2, 3, 7, 8, 10, and 12. These 32 eliminees constituted approximately 17 percent of the total enrollment in the classes studied. Examination of the frequency with which various reasons were assigned for elimination, as shown in table 13.2, reveals that approximately half of the eliminations were attributed to academic deficiencies. However, it is also apparent that consideration was given to personal qualities and ability to fly as a gunner on missions.

The criterion of elimination from the school had the practical advantage of being based upon relatively uniform conditions for

[4] For this group, M was 77.6 and SD was 6.4. Data on part scores on this test are presented in table 13.13.

all officers being compared, and of providing easily accessible data. This criterion had, however, the disadvantage of being based largely upon subjective judgments of individuals who functioned without the guidance of a clearly defined and consistent policy. Its value depended primarily upon the ability of instructors and administrative officers to predict success or failure of the student as a gunnery officer in a combat squadron. The extent to which these judgments were reliable, in the statistical sense, is unknown. On the whole, this criterion was considered to be a useful preliminary tool. Scores providing more definite evaluations of all students on all aspects of gunnery officer proficiency, insofar as it may have been revealed in course performance, would have represented a more desirable practical measure for validating selection tests. This goal was not, however, achieved during the period of operation of the Combat Gunnery Officers Course.

TABLE 13.2.—*Number of eliminations for various reasons among 190 students enrolled in the Combat Gunnery Officers Course (Classes 44-1, 2, 3, 7, 8, 10, and 12, May-August 1994)*

Reason for elimination	Frequency
Academic failure	14
Academic failure and air sickness	1
Academic failure and attitude	2
Board action	2
Elimination at own request	1
Basic gunnery deficiency	3
Attitude and character	3
Slow reaction	3
Air sickness	3
Total eliminated	32

Summary

In early 1944, the combat air forces made known an urgent requirement for trained gunnery officers to improve and maintain the proficiency of gunners during their combat tour. Tentative plans were made immediately for the selection and training of gunnery officers, based on an "armchair" analysis of the putative duties of gunnery officers. To verify and supplement this analysis and to obtain additional materials which would be useful in curriculum construction, a psychologist was sent to the 8th Air Force in January 1944 to study systematically the work of the men who were already functioning as gunnery officers ,albeit without having had formal training for their duties. On the basis of this study, observations were made with reference to the gunnery officer as a teacher, as a gunner, as a technical expert, as a leader, and as a person. Consideration of the problem of a criterion of gunnery officer proficiency led to the conclusion that graduation-elimination from the combat gunnery officers course was the most

adequate of possible criteria considered, although weaknesses in this criterion were evident.

THE SELECTION OF GUNNERY OFFICERS

Introduction

In formulating standards for the selection of gunnery officers, it was decided that the applicant should be a commissioned officer between the ages of 22 and 35, be able to pass the necessary physical examinations, and be a graduate of an AAF Training Command basic gunnery school in the upper 25 percent of his class or have equivalent on-the-job experience. It was further decided that the officers should attain a minimum score on a specially devised test appropriate to this job. This Gunnery Officers Selection Test, AC40A, and the revised form, AC40B, were developed in response to this need.[5] At the time when the test was prepared, there were available only the job description presented in the first part of this chapter and some information about the proposed curriculum for the gunnery officers course, since operation of the school had not yet begun. It was decided that the test should be able to do at least two things: to measure the ability to learn quickly (the gunery officers course would present much material in 5 or 6 weeks); and to measure those traits of personality deemed important for good teaching, for maintenance of liaison with other squadron, group, or staff officers, and for rapport with gunners.

Gunnery Officer's Selection Test, AC40A [6]

In the development of the initial form of the Gunnery Officers Selection Test, it was judged to be important that candidates taking the test should consider the items reasonably appropriate to the job of selection of gunnery officers; that insofar as possible the specific content of items should pertain to gunnery problems; and that the test performance should depend primarily upon the general intelligence and upon the relevant personal qualities of the candidates. In order to facilitate construction, various tests were studied as sources of ideas. The test as initially drafted was composed mainly of original items, except the Mechanical Principles section, which was based on the Aviation Cadet Qualifying Examination, AC12J, and on the Mechanical Principles

[5] See AAF Ltr. 50–31 dtd. 6 June 1944, and revised AAF Ltr. 50–31 dtd. 18 October 1944.

[6] The initial construction of the Gunnery Officers Selection Test was carried out under the supervision of Capt. Mason Haire, by Lt. William B. Schrader, Pfc. Arthur Feiner, Pfc. David Gordon, Sgt. Alexander Levine, and Sgt. Hyman For[illegible]enzer. Initial try-outs of the test and editorial revisions were the responsibility of Capt. Lawrence M. Stolurow, assisted by Lt. Gerald R. Pascal. Capt. Frederick B. Davis gave valuable technical and editorial suggestions.

Test, CI903A. The initial form of the test was tried out on a group of 38 Instructors School officers and 50 weather officers, changes were made in wording of items, and the test was re-mimeographed. The new form was administered to 685 officers in Training Command gunnery schools primarily to select students for the first few classes of the Gunnery Officers Course. On the basis of this experience, the test was edited to eliminate ambiguous wordings noted by the candidates. A number of new mathematics items were prepared during this period and were substituted for the mathematics items in the original forms. Form AC40A was the result of these preliminary try-outs and revisions.

Gunnery Officers Selection Test, AC40A, was organized into two booklets. In general, subtests which were thought to stress general learning ability were included in booklet I, while those designed to reflect personal qualities of the candidate were included in booklt II.

Booklet I.—Booklet I was constructed to serve as a general learning ability test. It contained three parts: Reading Comprehension, Mechanical Principles, and Mathematics. Table 13.3 shows the parts, the number of questions in each part, the reliabilities, and the scoring formula.

TABLE 13.3.—*The Gunnery Officers Selection Test (AC40A), Booklet I: Subject matter and length of parts, and reliabilities of parts and total (N=190, May-August 1944)*

Part	Subject matter	Number of questions	Question Nos.	Reliability [1]
1	Reading comprehension	30	1–30	0.71
2	Mechanical principles	45	31–75	.69
3	Mathematics	30	76–105	.85
Total	Booklet I	105	1–105	[2] .88

[1] Reliabilities computed by Kuder-Richardson Formula No. 21.
[2] For total score on booklet I, M= 68.1; SD= 13.5. Scoring formula was number of correct responses.

Illustrative items from each part of booklet I are presented below.

Illustrative item—Reading Comprehension (part 1)

Since many types of modern aircraft do not have complete all-around defense, hostile pursuit ships may be expected to take advantage of blind spots, or weak spots, in the defense. The most effective methods of covering blind spots is to distribute other aircraft in the formation in such a manner that their guns will cover these blind spots. In most instances of attack, against either a formation or an individual airplane, one gun station will bear the brunt of the defense. Under such conditions the gunner of the station contributing most to the defense may be assisted by other members of the combat crew. It is important to insure that firing is continuous as long as the attacker is in range and that maximum firepower is delivered at critical moments. The defense will ordinarily be brought into action at the command of the fire control officer.

1. Defense fire should be
1–A. continuous and steady while the target is in range.
1–B. continuous while the target is in range, and at a minimum at critical moments.
1–C. held until critical moments, and then quickly brought to a maximum.
1–D. such as to prevent the attacker from coming in range.
1–E. maintained in short bursts as long as the target is in range.

Illustrative item—Mechanical Principles (part 2)

1. A gun sight is reliable only within a limited range principally because
1–A. it is difficult to align the gun barrel and sights accurately.
1–B. the sight is set higher than the gun barrel.
1–C. it is difficult to line up the sight with the target at long range.
1–D. a bullet drops more and more rapidly as distance from the gun barrel increases.
1–E. a bullet loses momentum so rapidly.

Illustrative item—Mathematics (part 3)

1. A sniper stands in a room 8 feet back of a wall that contains a window 4 feet wide. In a road 100 feet from the house and parallel to it an infantry column is marching past. The length of the column that the sniper can see is
1–A. 50 feet.
1–B. 54 feet.
1–C. 200 feet.
1–D. 400 feet.
1–E. 432 feet.

Booklet II.—Booklet II was designed to stress the personality characteristics considered important for success as a flexible gunnery officer. These traits, with a brief description of each, are listed below.

(1) *Leadership.*—Ability to arouse, plan, and direct the activities of a group of gunners toward the attainment and maintenance of the highest possible level of proficiency in all respects of gunnery.

(2) *Sociability.*—Ability to mix well and show a direct personal interest in, and an understanding of, the gunners with whom he is working, and in their personal problems.

(3) *Judgment.*—Ability to arrive at a decision which will lead to effective action by recognizing, summarizing, and properly weighing all the facts pertinent to the solution of problems, particularly training problems.

(4) *Self-confidence.*—A fair and just appraisal of his own abilities enabling him to make necessary decisions and to take appropriate action without delay or hesitation.

(5) *Tact.*—Ability to deal with people in a face-to-face situation in such a way that pleasant and effective personal and working relations are maintained at all times.

(6) *Emotional control.*—Ability to remain calm and collected and to render fair and objective decisions under trying circumstances.

(7) *Gunnery interest.*—Interest in flexible gunnery and related mechanical problems.

These qualities served as a guide in deciding the type of subtests to be used and in formulating items for subtests in booklet II. An effort was made to include a number of items believed to be related to each of these characteristics, and to include only such items as were judged to be relevant to at least one of them. An attempt was made to construct Biographical Data Blank items covering each of these qualities. Instructional Aptitude items were designed to stress judgment and tact. Gunnery Interest was designed to measure interest indirectly by measuring information. Sports and hobbies was intended to provide indications of sociability. The number of items in each subtest are shown in table 13.4, along with reliability coefficients and scoring formulas.

TABLE 13.4.—*The Gunnery Officers Selection Test (AC40A), Booklet II: Subject matter and length of parts, and reliabilities of parts and total (N= 190, May-August 1944)*

Part	Subject matter	Number of questions	Question Nos.	Reliability [1]
1	Biographical data blank	60	1–60	0.43
2	Instructor aptitude	30	61–90	.53
3	Gunnery interest	30	91–120	.52
4	Sports and hobbies	30	121–150	.67
Total	Booklet II	150		[2].80

[1] Reliabilities computed by Kuder-Richardson Formula No. 21.
[2] For total score on booklet II, M= 88.8, SD= 13.2. Scoring formula was number of correct responses for all parts of the test except for Biographical Data Blank in which each alternative was scored +1, —1, or 0.

Sample items for each of the four subtests, and the directions for Biographical Data Blank and Instructor Aptitude are presented below.

Illustrative item—Biographical Data Blank (part 1)

Directions.—In this part you are asked for certain information about your opinions, your background, your education, and your civilian employment. All of this information has been shown to be related to gunnery officer training. It is, therefore, in your own best interest to answer the items in this part carefully. There are no "right" answers to these items except the answers that tell the truth about you.

For each item, decide which one of the choices best fits your case. Sometimes, no one of the choices will exactly fit your case. Don't worry about this; just select the choice that most nearly fits.

Work as rapidly as you can without making mistakes. Don't spend a long time thinking about the answer to an item. Mark the answer quickly that you think is *best* by blackening the space identified by the same letter and number on your separate answer sheet.

1. Until you were 18 years old, on which one of the following did you spend most of the time when you were not in school?

1–A. Building things.
1–B. Reading and studying.
1–C. Playing football, basketball, and other sports.
1–D. Working for your parents.
1–E. Earning money by working for someone other than relatives.

Illustrative item—Instruction Aptitude (part 2).

Directions.—This part contains a group of problems like those with which a gunnery officer might be confronted. Following each of the situations that are described are several multiple-choice items. Study each situation as you come to it and decide which one of the choices given after each accompanying question or incomplete statement *best* answers the question or completes the meaning of the statement. If you canot decide, you may reread the situation described. Several choices may seem reasonably possible; you are to select the one that you think is *best*. On your answer sheet, blacken the space identified by the same number and letter as the *best* answer.

At an air base in a theater of operations, a gunnery officer has organized his gunners into a class for an in-service training course. The gunnery officer was graduated from gunnery school some 10 months earlier and his combat experience has been limited. Two of the men are newly assigned gunners, while the other gunners have had many combat missions and have received most of their gunnery training in combat. The older gunners fall into three groups—half of them were trained as armorers, about a quarter of them were trained as radio men, and the rest are graduates of AM schools. The two waist gunners in the group lead all the rest both in combat missions and in decorations. What they say about anything is law with the other enlisted men of the command.

1. On every new point of procedure mentioned by the officer, the two waist gunners continually bring up difficulties based on their experiences. The officers should—

1–A. appeal to the class for cooperation.
1–B. call the two men in for conferences.
1–C. attempt to justify the technique on the basis of his superior training.
1–D. question the two men in such a way as to make them show their lack of knowledge of gunnery theory.
1–E. explain that new techniques are usually developed by highly experienced combat gunners.

Illustrative item—Gunnery Interest (part 3).

1. A violent and uncontrollable turn of an airplane while it is taxiing is called—

1–A. a christie.
1–B. a nose-over.
1–C. an Immelmann turn.
1–D. a chandelle.
1–E. a ground loop.

Illustrative item—Sports and Hobbies (part 4).

1. A "passed ball" may be charged against

1–A. either the pitcher or the catcher.
1–B. the pitcher only.
1–C. the catcher only.
1–D. any outfielder.
1–E. any infielder.

Total scores.—The distribution constants and reliabilities for both booklets are shown in table 13.5.

TABLE 13.5.—*Reliabilities of total scores: Gunnery Officers Selection Test, AC40A (N= 190, May-August 1944)*

	Number of questions	Reliability coefficient [1]
Booklet I	105	0.88
Booklet II	150	.80
Total test	255	[2].89

[1] Reliabilities computed by Kuder-Richardson Formula No. 21.
[2] For total score, M=157.1, SD=23.3, N=189.

Selection policy, AC40A.—As has been previously pointed out, at the time the test was constructed and when it was first put to use, there was no Combat Gunnery Officers Course, and it was impractical to test successful gunnery officers in theaters of operation. There was, therefore, no way of estimating the validity of the test, and the selection policy had to be determined without the aid of validation data. It was suggested, at first, that students be required to pass the test at or above the average for the population tested, i.e., at or above the fifth stanine. A number of candidates, particularly those having combat experience, were admitted to the school during the early period of operation on the basis of stanine scores of four and even of three.

The validity of AC40A.[7]—The validation of this first form of the test was possible only after the Combat Gunnery Officers Course had been in operation a sufficient length of time for enough cases to be gathered to permit statistical study. Data on the validity of AC40A are briefly presented here.

Table 13.6 shows the biserials of AC40A scores against pass-fail in the Combat Gunnery Officers Course. Although it was probable that a better than chance relationship existed between test scores and success in the course, it was judged that little confidence could be placed in the estimate of validity because the reliability of the criterion was unknown.

TABLE 13.6.—*Biserial correlation coefficients between scores on the Gunnery Officers Selection Test (AC40A) and graduation-elimination in the combat Gunnery Officers Course ($N=190$, $P_s=0.83$* [1]*, May–August 1944)*

AC40A	r_{bis} [2]
Booklet I	0.32
Booklet II	.08
Total Test	.18

[1] Means and standard deviations for this population not available.
[2] For these data, a correlation as large as 0.14 would be expected to occur by chance 5 times in 100; one as large as 0.18 would be expected to occur by chance 1 time in 100.

Revision and Final Form of the Gunnery Officers Selection Test, AC40B

Form AC40A of the Gunnery Officers Selection Test included 225 items and required approximately 4 hours to complete. In order to shorten the test, an internal-consistency item analysis was carried out, using answer sheets of 200 officers. Tetrachoric r's between pass-fail on each item and total score on each booklet (using median split) were computed for each item. The test

[7] Validation, standardization, and revision of AC40A were primarily the responsibility of Capt. Lawrence M. Stolurow, assisted by Lt. Gerald R. Pascal and Sgt. Paul Freeman. Chiefly responsible for statistical analyses were Capt. Otto J. Boyers and Technical/Sgt. Hyman Kaitz.

was cut to 125 items and time limits were set for each part. The total of these time limits was 2 hours. The Biographical Data Blank subtest was eliminated because of low item reliabilities and because of dissatisfaction with the *a priori* scoring key. The revised form of this test was designated AC40B.

The reliability of AC40B.—Since AC40B was composed entirely of items drawn from AC40A, it was possible to obtain estimates of the reliability of AC40B by rescoring 500 answer sheets of candidates for admission to the Gunnery Officers Course. Table 13.7 gives the reliabilities obtained, together with the name and length of each part. Stanine conversion tables for Booklet I scores, Booklet II scores, and total scores were constructed on the basis of the appropriate means and standard deviations. The stanine conversion tables will be found in table 13.8.

TABLE 13.7.—*Revised Gunnery Officers Selection Test, AC40B: Subject matter and length of parts and reliabilities of parts and total (N= 500, August 1944)*

BOOKLET I

	Number of questions	Question numbers	Reliability [1] coefficients	M [4]	SD
Part 1. Reading comprehension	25	1–25	0.70	17.37	4.00
Part 2. Mechanical principles	25	26–50	.70	16.97	4.05
Part 3. Mathematics	25	51–75	.85	11.83	5.76
Total Booklet I	75		[2] .87	46.17	11.29

BOOKLET II

	Number of questions	Question numbers	Reliability [1] coefficients	M [4]	SD
Part 1. Instructor aptitude	15	1–15	0.52	10.58	2.46
Part 2. Gunnery interest	15	16–30	.50	11.50	2.24
Part 3. Sports and hobbies	20	31–50	.63	11.92	3.55
Total Booklet II	50		[3] .69	34.00	5.82
Total test	125		.89	80.16	15.30

[1] Reliabilities computed by Kuder-Richardson Formula No. 21.
[2] For total score, Booklet I, M=46.2, SD=11.3.
[3] For total score, Booklet II, M=34.0, SD=5.8.
[4] Scoring formula for entire test was number of correct responses.

TABLE 13.8.—*Table for converting AC40B raw scores to stanine scores (N= 500, August 1944)*

Stanines	Expected percent of cases	Raw score intervals	
		Book I [1]	Book II [2]
9	4	66 and over	44 and over.
8	7	61–65	41–43
7	12	56–60	39–40
6	17	50–55	37–38
5	20	44–49	33–36
4	17	38–43	30–32
3	12	32–37	27–29
2	7	27–31	24–26
1	4	Below 27	Below 24.

[1] For Booklet I, M=46.2; SD=11.3.
[2] For Booklet II, M=34.0; SD= 5.8.

The determination of minimum qualifying scores.—An estimate of the relationship between AC40B scores and the criterion was calculated by rescoring AC40A papers of 182 officers for whom graduation-elimination data were available. These papers had been excluded from the item analysis on the basis of which AC40B was constructed. They had been used in the validation of AC40A described earlier. Table 13.9 shows the estimated relationship between Gunnery Officers Selection Test AC40B scores and graduation-elimination in the Combat Gunnery Officers Course.

TABLE 13.9.—*Biserial correlations between AC40B scores and graduation-elimination in Combat Gunnery Officers Course (May-August 1944)*[1]

AC40B	N_t	P_g	Stanine scores			r_{bis}[2]
			M_g	M_e	SD_t	
Booklet I	182	0.857	5.15	3.77	1.79	0.42
Booklet II	182	.857	5.46	4.81	1.93	.18

[1] Coefficients not corrected for restriction of range.
[2] For these data, a correlation coefficient as large as 0.14 would be expected to occur by chance 5 times in 100; one of 0.18 would be expected to occur by chance 1 time in 100.

To provide an empirical basis upon which to recommend qualifying scores in the selection of candidates for the Combat Gunnery Officers Course, various combinations of Booklet I and Booklet II stanines were arrayed against pass-fail in the course, and tetrachoric correlation coefficients computed. Table 13.10 shows the proportion of students and the proportion of failures which would have been retained by various combinations of stanine scores among 182 officers who attended the Combat Gunnery Officers Course.

TABLE 13.10.—*Percent of total population retained and percent of failures retained by various pairs of critical stanine scores of Booklet I and Booklet II of AC40B (182 students; 26 failures)*

Critical stanine score (Booklet I)	Critical stanine score (Booklet II):			
	3	4	5	6
3. Percent of students selected	72.5	61.0	[illegible]	
Percent of failures retained	53.5	46.2	26.[illegible]	
Tetrachoric r	(0.32)	(0.24)	(0.24)	
4. Percent of failures retained	58.8	51.1	37.4	
Percent of failures retained	26.9	23.1	23.1	
Tetrachoric r	(0.49)	(0.44)	(0.25)	
5. Percent of failures retained	36.8	34.1	26.9	20.[illegible]
Percent of failures retained	7.7	7.7	3.8	3.8
Tetrachoric r	(0.54)	(0.51)	(0.54)	(0.47)
6. Percent of failures retained			15.9	12.6
Percent of failures retained			3.8	3.8
Tetrachoric r			(0.40)	(0.05)

Selection policy, AC40B.—Considering the predictive value of obtained measures of relationship, and the uncertainty of factors

contributing to the make-up of the population used in the empirical study, it was deemed advisable to select cut-off scores which would permit a majority of candidates to enter the Combat Gunnery Officers Course. It was therefore recommended that until such time as validity studies against a reliable criterion could be conducted, all applicants receiving a stanine score of four or above on Booklet I and three or above on Booklet II be admitted to the school. Inspection of table 13.10 will show that if this policy had been followed with 182 students who had been admitted to the school, 26.8 percent, or 7 out of 26, of the men who actually failed would have been permitted to enter the school, but that 58.8 percent of the total number of students would have been admitted. Under the circumstances the recommended stanine cut-offs were considered fairly efficient, and they were recommended for use.

Summary

This chapter has described the construction of the Gunnery Officers Selection Test, its reliability, and, insofar as possible, its validity. The statistical procedure used in arriving at a recommended cut-off score for selection of applicants has been indicated. The statistical analysis showed a significant relationship between success on the Gunnery Officers Selection Test and success in the Combat Gunnery Officers Course.

THE TRAINING OF GUNNERY OFFICERS

Introduction

The original curriculum for the training of combat gunnery officers developed as the result of three separate endeavors, as described below.

Preliminary draft of curriculum.—The first draft of the curriculum was prepared in December 1943, following the receipt by the Instructors School of a directive to prepare to train some 1,500 gunnery officers.[8] The directive required immediate action in establishing a course of training for such officers. In preparation of the initial curriculum, it was necessary to take advantage of such information as was available from combat reports and from officers who had some combat gunnery experience. Guiding principles were inferred on the basis of the broadly defined objectives stated in the directive. Suggestions regarding possible gunnery training procedures were obtained from officers engaged in the training of basic gunners and gunnery instructors at Buckingham.

[8] Most of the original planning for the training of gunnery officers was done by Maj. Roger W. Russell. He drafted the preliminary curriculum, conduct : the study of gunnery officers in the 8th Air Force, and advised in the preparation of the al draft of the initial curriculum of the school.

In general, the first draft of the curriculum emphasized instruction in various methods teaching gunners and of giving them refresher training, as it was anticipated on the basis of available information that gunnery officers would be primarily concerned with such problems. Also included in this first draft were provisions for a review of the duties and equipment of basic gunners, as well as for familiarization with the latest developments in gunnery theory and tactics.

Study of gunnery officers in the European Theater of Operations.—It was recognized during the early period of planning of the gunnery officers course that the preliminary curriculum formulated to meet immediate military requirements should be evaluated and revised on the basis of a firsthand study of the duties of combat gunnery officers. It was primarily for the purpose of effecting such evaluations and revisions that an officer was sent, in January 1944, to the European Theater of Operations to visit gunnery installations and interview gunnery experts in the 8th Air Force and the Royal Air Force.

The information gained regarding the duties of gunnery officers in both the RAF and the 8th Air Force is summarized in the first part of this chapter. On the basis of this information, eight fields of knowledge were formulated, and were assigned weights according to their relative importance, the weights being based as much as possible on the consensus of experienced and qualified gunnery experts. The number of class hours to be devoted to instruction in each of eight fields was then determined, account being taken both of the weightings and of the difficultives involved in learning the various types of material. Difficulty of materials to be learned was judged in terms of the complexity of the material involved and in terms of the likely backgrounds of the student officers. The fields of knowledge, assigned weights, and delegated numbers of class hours were as indicated in table 13.11.

TABLE 13.11.—*The fields of knowledge, assigned weights, and number of class hours used in preparation of initial curriculum for Combat Gunnery Officers Course (Buckingham, March 1944)*

Field of knowledge	Weight	Hours in 5-week course
(1) Knowledge of training principles and practices as may apply to training in flexible gunnery	12	69
(2) Knowledge of flexible gunnery (including sighting)	9	51
(3) Knowledge of the maintenance of gunnery equipment (including preflight checks)	8	46
(4) Knowledge of tactics and the tactical employment of gun-armaments	4	23
(5) Knowledge of operational procedures	4	23
(6) Knowledge of administrative and disciplinary procedures	1	6
(7) Knowledge of factors influencing morale	1	6
(8) Knowledge of the care and maintenance of the gunners	1	6

The fields of knowledge listed in table 13.11 agreed essentially with the first rough draft of the curriculum prepared prior to the study of gunnery officers in the European Theater of Operation. The 8th Air Force study largely confirmed the assumptions on which the preliminary curriculum was based.

Contribution of board of combat gunnery experts.—At approximately the same time that the 8th Air Force study was initiated, four combat gunnery experts were ordered to Buckingham to assist in the establishment of the course.[9] These officers made several revisions to the first draft of the curriculum, formulated some suggestions regarding specific training procedures, and met with the officer in charge of the 8th Air Force study, upon his return, to make final decisions about the curriculum.

The Curriculum for the Combat Gunnery Officers Course

On the basis of the above three endeavors, the curriculum outlined in table 13.12 was put into effect for the first class of students in the Combat Gunnery Officers Course. The broad out-

TABLE 13.12.—*Initial curriculum for Combat Gunnery Officers Course (March 1944)*

Content	Hours
1. Orientation	4
2. Flexible gunnery review and instruction (70 hours):	
a. Sighting, theory and sights	33
b. Synthetic training, theory and practice	10
c. Ground firing, theory and practice	6
d. Air-to-ground firing, theory and practice	9
e. Air camera-gun firing, theory and practice	8
f. Evaluation and assessment of air camera-gun film	4
3. Principles and practices in flexible gunnery training (44 hours):	
a. Orientation	1
b. Organization of training program	3
c. Instructor selection	1
d. Teaching methods	18
e. Training records	2
f. Practice teaching	19
4. Use and maintenance of equipment (51 hours):	
a. Introduction	1
b. Weapons	14
c. Ammunition and explosives	2
d. Turrets	32
e. Interphone communication equipment, theory and practice	1
f. Oxygen and personal equipment	1
5. Tactics (23 hours):	
a. Introduction	1
b. Factors affecting air fighting tactics	1
c. Fighter tactics	2
d. Bomber tactics	3
e. Fighting control and evasive action	2
f. Search procedure	1
g. Duties of flexible gunner	1
h. Air exercises	12
6. Operational procedure (36 hours):	
a. Introduction and outline of combat intelligence	2

[9] Squadron Leader William J. Winter, RAF, Capt. Otis W. May, Capt. Edward C. McLaughlin, and Capt. Eugene J. Pollock.

b. Briefing, theory and practice	8
c. Interrogation, critiques, personal interviews, and reporting, theory and practice	15
d. Maps and target charts	1
e. Evasion, escape procedures and prisoner-of-war behavior	2
f. Aircraft recognition	2
g. Briefings and interrogations in conjunction with air exercises	6
7. Administration and discipline (6 hours):	
a. Unit organization, channels of command, staff relations, etc.	1
b. Administration and reports	3
c. Military law	1
d. Discipline	1
8. Morale (3 hours):	
a. The meaning of "morale"	1
b. Principles of controlling morale	1
c. Practical suggestions for maintaining the morale of gunners	1
9. Care and maintenance of the gunner (6 hours):	
a. Effects of flight	2
b. Prevention of personnel failures leading to casualties	1
c. First aid	1
d. Air fatigue	2
10. Final examination	2
11. Final board	1
Total hours of course of instruction	246
12. Round-table discussions:	
a. Orientation discussions by:	
(1) Pilot	2
(2) Navigator	2
(3) Bombardier	2
b. Informational discussions by available combat personnel (hours as required)	

lines of the curriculum remained essentially the same throughout the war, although many changes were made in the specific course content from time to time, one of the most important being the addition of a sixth week almost exclusively devoted to simulated operational missions. The correspondence between this curriculum and the descriptions of the duties of gunnery officers was close. It can be seen that each of the areas of knowledge stressed as being of importance to the accomplishment of these duties was taken into account in the preparation of the curriculum.

Contributions of Psychologists to Gunnery Officers Course

Psychologists in the Central School had little to do with the gunnery officers course once it was established. Various course examinations were prepared by the psychological tests section of the Research Division, and a final comprehensive examination prepared by this section was used as one basis for elimination. In accordance with the expressed desire of school authorities, these tests were designed to measure the mastery of a minimum amount of information considered to be of special importance. Obtained scores were usually so high that it was deemed unprofitable to determine measures of item reliability. Reliability coefficients were determined for the Final Comprehensive Examination, form B, on the basis of administration to two classes. These data are included in table 13.13.

TABLE 13.13.—*Reliabilities of part and total scores of Combat Gunnery Officers Course Final Comprehensive Examination, Form B (Class 44-4, January 1944; Class 44-6, February 44; N= 54)*

Part	Number of items	Range of raw scores	Mean raw score	SD	r[1]
Principles and practices of gunnery training	15	2–15	9.5	3.1	0.75
Tactics	10	5–10	8.4	1.4	.48
Administration and discipline	10	3–10	7.0	1.4	.17
Care and maintenance of the gunner	5	1–5	3.9	1.0	.26
Use and maintenance of equipment	30	19–25	25.4	2.3	[illegible]
Aerial gunnery review and instruction	30	18–27	23.0	2.0	.12
Total	100	61–90	77.6	6.4	.89

[1] Reliability computed by Kuder-Richardson Formula 20.

Validity was considered only insofar as each item on a test did relate to actual course content and was technically accurate.

Summary

A preliminary sketch of the gunnery officer's job, a more specific job analysis of the duties of gunnery officers functioning in the 8th Air Force, and the considered judgment of a board of four combat gunnery experts contributed to the formulation of the initial curriculum described in this section. The central problem in the allocation of time to different training activities was the maintenance of a proper balance among training methods, gunnery skill and knowledge, and administrative procedures. Further work related to the training of gunners included the preparation of the final comprehensive examination and of several course examinations.

SUMMARY

The contributions of psychological research to the selection and training of gunnery officers were made chiefly in the initial formulation of policies and procedures. The development of a preliminary conception of the gunnery officer, and the execution of a survey based upon systematic interviews and firsthand observation of gunnery officers in the 8th Air Force provided necessary information for planning of training and selection procedures. This work was particularly useful in formulating the curriculum. Concurrently with the planning of the training program, the development of a selection test was carried out, so that this test was available in substantially the final form by the time the first students were admitted to the school. All of this work was done with full recognition of the urgent need for gunnery officers.

After the school for gunnery officers had begun operation, data

for the validation of the selection test were collected. Evidence was found that this test was useful for reducing the proportion of students eliminated from the school. The test was also shortened and made more convenient to use on the basis of an internal consistency item analysis. Further services to the school included the construction of a final comprehensive examination, which was composed of items believed to be most important by the school authorities, and the construction of several course examinations.

CHAPTER FOURTEEN

Contributions to the Development of Flexible Gunnery Equipment, Theory, and Technique

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Although the improvement of procedures for the selection and training of gunners was the primary objective of psychological research in gunnery, problems associated with the improvement of gunnery equipment, theory, and technique were also considered. Some of the work done in this area was experimental; much of the work was advisory in nature and consisted of suggesting solutions to equipment and tactical problems on the basis of established psychological principles. In this chapter, some of the more important contributions to the development of flexible gunnery equipment, theory, and technique will be summarized.

EQUIPMENT PROBLEMS

Introduction

It is unfortunate that the very vital relationship between the gunner and the equipment he used was largely ignored, insofar as a systematic scientific approach was concerned, for the greater part of the war. Many of the best engineers in the country were busied with rush orders for the development of efficiently operating gunnery equipment—turrets, sights, guns—and, considering the backwardness of the field of flexible gunnery at the start of the war, turned out a remarkable job. But in haste to get equipment into the combat theaters, the problem of so designing the machines that they would be easiest for the gunner to operate was not given mature consideration. The following statements are presented in support of this contention.

The right and left waist guns on early B-17's and B-24's were so placed that the gunners could not avoid bumping into each

other when firing. Vibration virtually precluded accurate sighting with N-6 and other fixed sights while the guns were firing. The Sperry computing sights, in the upper turret, demanded that the gunner make conflicting manual movements while tracking and ranging simultaneously, and, in the ball turret, to make precise ranging adjustments by operating a pedal with his heel. The slowly floating reticle in the Sperry computing sights, moving across the viewing glass according to the direction and rate of tracking, was a source of confusion to the gunner. The periscopic sight in the A-26 provided no reference points by which the gunner could tell which direction his sight was pointing and thus determine deflections. Both the A-26 sight and the top sighting station on the B-29 required that the gunner move himself and the sight in azimuth by pushing sideways on the floor with his feet, an awkward task. The arrangement of range controls on the B-29 pedestal sight assured the confounding of range with elevation inputs. Gunners in combat quickly learned that the knurled rim of the range control on this sight made ranging difficult, and frequently filed the knurls off. Additionally, the fact that the range control was placed on the right wheel of the pedestal sight and on the left handle of the ringsight of the B-29 suggested a general lack of consistency in approach to the design of the B-29's sighting equipment.

By early 1944 gunnery officials in Headquarters, Army Air Forces, had been made sufficiently aware of the importance of the problem of gunner-equipment relationships to request the National Defense Research Committee to establish a project for the specific purpose of evaluating existing B-29 and other types of sighting equipment, and designing, testing, and recommending improvements as appeared necessary. A separate organization directed and operated entirely by civilian personnel working under university contracts was decided upon for two reasons. First, the available facilities of psychological personnel of the Central School's Research Division had already been committed to a program of developing gunnery proficiency measures, and evaluating and improving existing training devices and procedures. Second, greater ease and freedom in the procurement of specialized machinery and sighting equipment was assured the civilian group through detailed administrative agreements between National Defense Research Committee, Headquarters, Army Air Forces, and the War Production Board.[1] Below are summarized other studies which were made by personnel of the Research Division.

[1] The results of this work are reported in publications under the general heading of Applied Psychology Panel, NDRC, Project AC-94: Psychological Factors in the Operation of Flexible Gunnery Equipment.

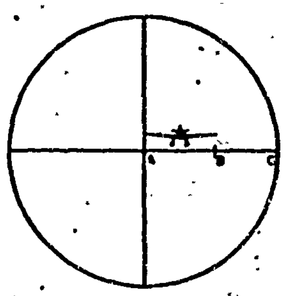

Fig. 14.1—Illustration of problem of estimating range of aircraft using a ring sight.

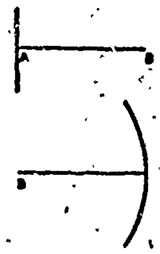

Fig. 14.2—Detailed illustration of possible source of illusion in estimating range of aircraft with ring sight

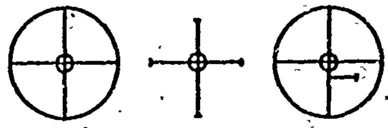

Fig. 14.3 Illustration of three designs of iron ring sights compared for operation of sphere illusion in estimating range of aircraft. Design for optical sight reticle was the same except for absence of small circle at intersection of cross-hairs

An Investigation of Some Perceptual Problems in Sighting

From an earlier study of the Reflectone Range Estimation Trainer (reported in chapter 9) it will be recalled that even after considerable practice in adjusting the model plane to a range simulating 600 yards, an average sighting error of about 30 yards was consistently made by a large group of subjects. The errors appeared to be constant, with the tendency being in the direction of stopping the plane too far away from the desired standard. Of the 500 judgments made by 5 subjects in another experiment, 489 were wrong in the direction of overestimating the range of the approaching plane. This consistency in overestimating range suggested the possibility of an illusion operating in the sighting situation. The illusion may best be presented diagrammatically. Referring to figure 14.1, assume that the student's task was to adjust the plane so that for him AB=BC. Because of the curvature of the reticle at point C, it seemed likely that AB would seem longer than BC even when the two were actually equal. The illusory possibility is seen more clearly in figure 14.2, which begins to resemble the well-known Muller-Lyer illusion. Therefore, to make AB subjectively equal to BC, the subject might tend subjectively to shorten AB, which would be indicated by consistency in stopping the plane at a greater-than-standard range, where the wingspan would appear shorter than the true distance AB.

Experimental investigations.—To investigate the effect of a possible illusion, a pair of experiments were conducted to test the hypothesis that visual perception in the context studied was affected by an illusion factor induced by the specific design of the ring sight, to compare the relative efficiency of iron and optical sights, and to study the value of a guide as an aid in effecting specific judgments.[2]

The Reflectone Range Estimation Trainer was used to allow each of 12 subjects to make 300 attempts in 3 equal sessions in a single day to set the moving plane model at a standard range of 640 yards, using for each group of 100 judgments a different sight design as shown in figure 14.3. For the model plane used, setting it so as to fill exactly one-half the radius of the reticle was equivalent to a simulated setting of 640 yards. The order of practice with the sights was counter-balanced among the subjects, and the initial position of the plane from which the subject was to adjust it to a range of 640 yards was randomly distributed between positions beyond, and positions closer to the subject than the standard range. Subjects were instructed to set the plane so

[2] This investigation was designed, conducted, and reported by Lt. George Wischner.

that it filled exactly one-half the radius of the A and B sights, and so that it exactly equaled the length of the guide in sight C. Subjects were encouraged to take as much time as desired for each judgment.

Separate experiments were conducted with iron and optical sights. The procedure was the same in both experiments, although it was unfortunate that the subjects were not from the same sample. Those for the iron sight experiment were graduate gunners awaiting shipment, and those for the optical sight experiment were newly arrived students, awaiting entry into school. In both experiments the same sight designs were used with the exception that the optical sight did not have the small ring at the cross hairs.

The results of the experiment with the iron sights seemed to verify the illusion hypothesis. Of the 12 subjects, 8 showed smaller constant errors with design B than with design A, and the differences for 6 of these 8 had critical ratios greater than 7.0. Of the 4 subjects performing better with design A, 3 performed better with statistical significance, though the critical ratios were not reported.

Data for the optical sight experiment were similar to those for the iron sight experiment. Eight of the subjects showed better performance with design B than with design A, and the differences for seven of these eight were significant, with critical ratios exceeding 4.0; the eighth had a critical ratio of 2.52. Only two of the four cases favoring design A showed significant differences in favor of that sight. The results for all subjects taken together are summarized in table 14.1.

TABLE 14.1.—*Comparison of 2 designs of sight reticles for optical and iron sight: Means of ranges estimated to be 640 yards and significance of differences between means of 100 estimates by each of 12 subjects for each combination of sight and design (Buckingham, fourth quarter, 1943)*

Design	Optical sight			Iron sight		
	M[1]	Diff	t	M[1]	Diff	t
A	656.66	16.55	[2]1.98	730.91	27.19	[3]2.36
B	640.11			703.62		

[1] In yards
[2] Difference would occur by chance between 5 and 10 times in 100.
[3] Difference would occur by chance less than 5 times in 100.

The fact that the errors in estimating range were greater for both designs A and B in the iron sights than in the optical sights suggested the additional possibility of the operation of a size constancy phenomenon. In the task of estimating the range of

the model plane, all movements were horizontal. In the case of the optical sight, which worked on the collimating principle, the reticle was composed of parallel light rays, which made the airplane and the reticle appear to be in the same vertical plane. In the case of the iron sight, the sight and the airplane were clearly at all times in different vertical planes, with the sight being in a plane only a few inches away and the airplane in another plane at a considerable distance. Knowing the airplane to be of a given size, and having considerably more objects close-by in the visual field with which to compare the apparent size of the airplane, observers using the iron right sight might very well have tended to perceive the approaching plane to have reached a given apparent size earlier than would observers using the optical sight, who had few if any objects close to the eyes by which to judge the distance of the approaching airplane. The supporting data are given in table 14.2.

To those who have seen both the optical and the iron sights the superiority of the optical sights will not seem surprising. The iron sight was a rather grossly constructed device, having lines sufficiently thick to obscure the wingtips of an approaching plane, and thus make for error in estimating its range. The optical sight, on the other hand, could be made with fairly fine lines. Also, the optical sight did not require that the gunner's eye be kept at a constant distance from it in order to estimate range accurately, as did the iron sight.

On design C, the data were not fully reported, but the project report concluded that the guide did not prove an effective aid in making the proper settings of range, though a few of the subjects did appear to make good use of it.

TABLE 14.2.—*Comparison of three designs of iron and optical sights: Means and standard errors of means estimated to be 640 yards; t values of differences between means of 100 estimates by each of 21 subjects for each combination of sight and design (Buckingham, fourth quarter, 1943)*

Design	Iron sight		Optical sight		
	M [1]	SE_M	M [1]	SE_M	t
A	730.91	23.08	656.66	8.07	[2] 3.01
B	703.72	16.20	640.11	8.09	[2] 3.61
C	683.68	15.00	676.40	6.70	[3] .45

[1] In yards.
[2] Difference would occur by chance less than 1 time in 100.
[3] Difference would occur by chance too frequently to be attributed to difference in construction of sights.

Sighting Accuracy as Influenced by Eye Dominance

The evaluation of training devices was routinely directed by higher headquarters (ch. 9). In at least one instance the Psy-

chological Unit was directed to conduct experimental tests of equipment being considered for possible operational use.

Reference is made to a special three-handled grip for hand-held guns such as were commonly used in waist positions of heavy bombers. This grip included a third handle directly in line with the bore of the gun, and situated slightly to the rear of the other two standard handles. It was assumed that gunners with right eye-dominance would find the alignment of the sights and the right eye facilitated by controlling the gun with the right hand on the center handle, and that gunners with left eye-dominance would align the left eye and the sights easier with the left hand gripping the center handle.

To measure the effectiveness of this adaptation of the "spade grip," as the handle unit for free swinging guns was called, an experiment was conducted using 10 gunnery students, evenly divided as to eye-dominance.[3] Dominance was determined by having the subject sight with a vertically held pencil on a distant object and then asking him to close his right eye; if the right image of the pencil remained in line with the object sighted upon, left eye-dominance was indicated, and if neither image appeared to remain aligned with the object, right eye-dominance was indicated. The test was repeated with the subject closing the left eye; the left image of the pencil remaining aligned with the object sighted upon indicated right eye-dominance. The test was given twice for each eye; if the test results agreed with the subject's own opinion as to his eye-dominance, he was selected for the experiment. All subjects were appraised in advance of the purpose of the experiment.

In a firing order counter-balanced to control the effects of skill and the mounting of the gun, each subject fired 200 rounds using the standard grip and 200 rounds using the three-handled grip. Right-eyed subjects always sighter with the right eye and used the special grip according to the recommendation, and left-eyed subjects sighted with the left eye and operated the gun with the left hand on the center handle. A moving target range was used for firing, with all firing being done at a range of 200 yards; new barrels were used throughout. The targets were carefully scored by project personnel.

The data comparing the two types of grip are summarized in table 14.3.

It is seen that no difference in scores resulted from the use of the different spade grips. These findings were reported to higher

[3] The Project Officer for this experiment was Capt. Theodore R. Vallance, assisted by Lt. Esten W. Ray.

TABLE 14.3.—*Comparison of conventional and 3-handled spade grip: Mean number of hits out of 200 rounds fired, standard deviations, and differences and significance of differences between means (Buckingham, fourth quarter, 1944)*

Grip	N	M	SD	Diff	CR
Conventional	10	48.8	28.4	1.10	.161
Three-handled	10	47.7	22.0		

headquarters, and no further developmental work was done to develop the special grip.

The Influence of Counter-Balanced Gun Cameras on Sighting Accuracy

The sighting stations of the B–29 were not originally designed to accommodate a gun camera, either for training or operational use. As a part of the training program it was considered necessary to use gun cameras, and it was later decided to include gun cameras in operational missions since it was possible to photograph gunner's combat sighting without danger of vibration obscuring the results. The B–29 sighting stations were very well counter-balanced for ease of operation, and the addition of a camera weighing nearly 5 ponds would have meant a considerable change in the gunner's task unless the additional weight were effectively counter-balanced. When the use of gun cameras with B–29 sights was first considered, the design of proper counter-balances was urged by the psychologists and finally effected. It was immediately obvious that the difference in "feel" between the counter-balanced and the noncounter-balanced sight after the camera was mounted was very great, and that the difference between the normal sight and the counter-balanced sights was very small. No experimental comparison of the counter-balanced sight and non-counterbalanced sight with gun camera attached was attempted. However, in the event that the use of a counter-balanced gun camera might possibly disturb the gunnery in combat, an experiment was conducted to compare performance on a normal sight with performance on a sight having a counter-balanced gun camera attached.

The device used for the test was known as the Hobson-Strnad Trainer, originally created by two enlisted men at Buckingham, and improved upon considerably by personnel of the NDRC Project at Laredo (see p. 50). Through a system of balanced potentiometers and selsyn follow-up circuits it was possible to measure with fair accuracy the ability of the gunner to track and

[4] The project personnel were Capt. Theodore R. Vallance and S/Sgt. Burton R. Wolin. The report was written by Maj. John V. McQuitty.

frame (range) the simulated target airplane of the trainer as it moved about the gunner in cam-controlled paths similar to pursuit attacks.

Twenty-seven gunners who had been thoroughly trained in B-29 pedestal sight manipulation were given 12 trials of 6 attacks each, 1 trial per day, alternating between morning and afternoon sessions, and between conditions of (a) normal sight and (b) the same sight with a counter-balanced gun camera attached. On the average, each gunner tracked and framed for 5 minutes during each trial, thus receiving a total of 60 minutes practice equally divided between camera and no camera. Performance was recorded on polygraphs and scores were expressed as percent of total time on target; to be on target the gunner had to be tracking in azimuth within a tolerance of 6 mils, tracking in elevation within a tolerance of 8 mils, and framing within a tolerance of 5 mils.

The results of the experiment are summarized in table 14.4 and

TABLE 14.4.—*Average percent of time on target for 27 subjects on the Hobson-Strnad Trainer with and without counter-balanced gun camera (Laredo, third quarter, 1945)*

Sighting component	Camera	No camera	Difference
Azimuth tracking	90.6	91.7	[1] 0.9
Elevation tracking	82.2	82.9	0.7
Framing	27.2	29.2	[1] 2.01
All three of above	20.8	22.7	1.9
All three while triggering	18.1	20.5	2.4

[1] Difference would occur by chance less than 5 times in 100. Other differences are not satisfactorily significant.

show that only very slight differences were obtained between the two conditions, and that not all of these were statistically significant. It was concluded that, in so far as the trainer on which the experiment was run simulated the sighting problem of the B-29 gunner, the use of a counter-balanced gun camera did not noticeably interfere with sighting accuracy. From a logical point of view, the scarcely perceptible difference in "feel" between the normal sight and one with a counter-balanced gun camera attached should not be expected to produce a marked change in the gunner's ability to use the camera-equipped sight.

PROBLEMS OF THEORY AND TECHNIQUE

Position Firing

By the end of 1942 the inadequacies in the sighting system which flexible gunners were using in combat and which was being taught them in this country were well known both in the States

and overseas. The existing system was generally recognized as theoretically unsound and practically unteachable. Mathematicians of the Operational Analysis Section of the 9th Air Force developed a system of sighting which required that the gunner apply given amounts of deflection according to the apparent angle of the fighter plane off the beam of the bomber. A fighter pilot had to fly a mathematically determinable course in order to get hits on a bomber; it was therefore possible to predict where the fighter would be at any given time during his attack, and thus to aim the defensive armament of the bomber accordingly. The RAF made use of a similarly based system, called the Zone System, with which members of the 8th Air Force Operational Analysis Section came in contact. Mathematicians in this country were simultaneously busy on the problem. The efforts of these groups resulted in a new system of sighting, known as Position Firing, which was later adopted by the Army Air Forces as the official bomber defensive fire doctrine for use with noncomputing and noncompensating sights.[5]

In cooperation with representatives of the Navy, the 8th and 9th Air Forces, and the National Defense Research Committee, the Psychological Research Detachment (Gunnery) participated in the following activities: (a) establishment of the objectives of teaching Position Firing and recommendation of a tentative curriculum, including modifications of ranges and trainers to simulate as closely as practicable the Position Firing problem, (b) establishment and observation of an experimental curriculum at two flexible gunnery schools, and (c) the writing of a simple description of the mathematical concepts in the Position Firing system as a means of familiarizing gunnery officers and instructors with the new method. This description of Position Firing was published by the Instructors School as a booklet: "Position Firing—Facts and Figures."

The development of Position Firing contained an example of the application of judgment of a professional nature without the comforting recourse to specific experimental data. When the question of how to conduct training in Position Firing arose, the problem of how to teach the basic concept of the "angle off" to gunners needed a quick answer. Because the amount of deflection required depended on the apparent angle between the line from gunner's eye to target and the path of the bomber's flight, it was at first planned to teach in terms of "90 degrees off, apply 3 rads; 45 degrees off, 2 rads; 22½ degrees off, 1 rad; 11¼ degrees off, ½ rad; and for 0 degrees off, fire point-blank." This proposal appeared to require that gunners first be taught what a

[5] See Ch. 2 for a more detailed discussion of the gunner's sighting problem.

degree was, and what angles with various numbers of degrees looked like before any effective instruction in sighting could be done. The alternative that was suggested by the Psychological Unit and subsequently adopted was to teach not in terms of degrees, but of apparent position, i.e., "straight out, apply 3 rads; half way back, apply 2 rads; ¾ of way back, apply 1 rad; almost all the way back, apply ½ rad; gradually decrease deflections from maximum to minimum along the line of apparent motion." No difficulty was ever reported in describing the sighting situation in these simple terms.

Opening Range

Another situation in which psychologists provided a practical answer to an important question, was the matter of determining at what range the forward gunner of a B–29 should open fire at nose, or head-on, attacks. The opening range doctrine originally in effect did not seem to allow for the reaction time required by the gunner to judge the opening range and press his trigger. Considering that the distance between the fighter and the B–29 was decreasing at a rate frequently as high as 750 miles per hour, it was recommended that the range for opening fire be extended to allow for the gunner's reaction time in order that the guns might be firing through the entire period during which the target plane was within the effective range of the B–29's armament. A few additional bullets in the right place could very well spell the difference between death for the fighter pilot or for the bomber crew.

Technique in Using Iron Ring-And-Post Sights

The earliest sights used in flexible gunnery were called iron ring-and-post sights, consisting of a post, mounted near the muzzle end of the barrel, which the gunner lined up with the center of a ring containing cross-hairs mounted about 30 inches to the rear, near the breech. The original sighting procedure required the gunner to keep the center of the ring in line with the top of the post and, according to the amount of deflection he was laying off, keep the image of the target plane a given distance from the center of the ring. In order to keep the mathematics of the method sound, it was necessary for the gunner's eye to remain at a constant distance from the ring. This was called the eye-base method. From several sources came a proposal that a method be adopted wherein the gunner would keep the bead (top of the post) fixed on the target, and adjust the alignment of the gun to that the bead and target were repositioned to one side of the center of the ring, according to the amount of deflection desired.

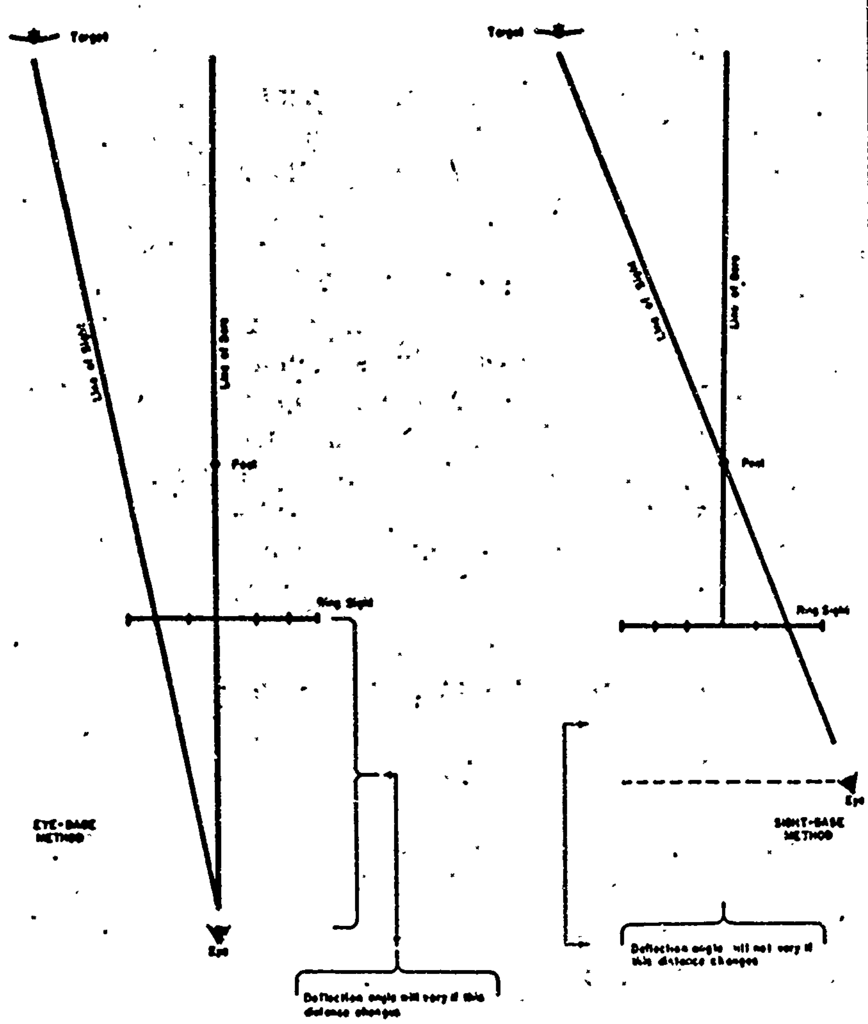

Fig. 14.4 Diagrammatic Illustration of eye-base and sight-base methods of using iron ring-and-post sights. Looking down on the gun, a deflection angle of 2 rads (Approximately 70 mils) is represented.

This was called the sight-base method, and had the advantage of not requiring the gunner to maintain his eye a constant distance from the ring. Figure 14.4 presents the two methods diagrammatically.

A brief experiment[6] was conducted to compare the two methods. A sighting bar, simulating a machine gun equipped with sights, was set up 25 feet from a fixed target in the laboratory. Using the eye-base method and the sight-base method in a predetermined order, each of 6 subjects made 10 estimates of each of 3 deflections (½ rad, 1 rad, and 1½ rads) by aligning the sight and the target with the indicated deflection set off. A total of 120 estimates were made with each sighting system. The distance from the estimated point of aim to the correct point of aim was measured after each estimate. The results are given in table

TABLE 14.5.—*Eye-base vs. sight-base system for using iron ring-and-post sights: Average error in inches for 10 estimates by each of 6 subjects of deficiencies of ½, 1 and 1½ rads (Buckingham, fourth quarter, 1943)*

System	Mean error in inches in estimating:		
	½ rad	1 rad	1½ rad
Eye-base	0.735	1.017	0.876
Sight-base	.393	.697	.545

14.5. The difference obtained in every case favored the newer procedure, but no test of the significance of the differences was reported. The Psychological Unit recommended the adoption of the sight base method, however, because, in addition to these scant data favoring it, the possibility of the sight-base method being much less subject to error in the confusion of combat appeared to experienced gunnery officers to be very great, whereas the eye-base bethod appeared to be a much less stable one.

Technique in Using Compensating Sights for Support Fire

The development of procedures for the use of compensating sights became a critical need during the last months of the war in Europe. While compensating sights, which mechanized the rules of Position Firing, were quite adequate against attacks being made on the gunner's own bomber, the very nature of a fighter attack made difficult the problem of lending support to a neighboring bomber under attack. Of course, computing sights, if efficiently operated, would compute proper deflections for firing at fighters attacking another bomber, but the gun positions equipped with compensating sights could not effectively aid other

[6] This experiment was conducted by Lt. George Wischner.

bombers if used in the standard manner. This meant that, for all practical purposes, the six guns equipped with compensating sights in most heavy bombardment planes were of no value to any but the plane carrying them.

Rules for support fire deflection.—To increase the versatility of compensating sights, mathematicians calculated the amount of deflection that would be necessary to score hits on fighters attacking other planes in the gunner's formation and produced a set of rules for applying deflection using compensating sights. The application of these rules required that the gunner estimate what came to be called the "aspect angle" of the attacking plane. The aspect angle was defined as the angle between the line from gunner to target and the line extending through the longitudinal axis of the target aircraft. Knowing this angle, it was possible to set the compensating sight for 100 percent of own speed compensation, then supply additional deflections according to aspect angles as follows:

Aspect angle in degrees	Lead (in 35 mil rads)
0	0.0
5	0.5
10	1.0
15	1.5
20	2.0
25	2.5
30	3.0

Reliability of proposed support fire procedures.—Position Firing required relatively simple judgments of fighter position with reference to the gunner's plane, but the judgment of aspect angle presented a new problem of probably great, though unknown, difficulty. The whole problem of adequate support fire rested on the ability of the gunner to judge these crucial aspect angles. Accordingly, two experiments were conducted to measure the ability of gunners to make these judgments.

Procedure: I. Recognition of simulated aspect angles.—The first experiment involved the judgment in the laboratory of the apparent aspect angle of a model fighter set at a simulated range of 400 yards from the viewers.[7] The apparatus used was a modified Reflectone Range Estimation Trainer; the aspect angle could be varied from 0 to 30 degrees in increments of 5 degrees; the apparent direction of the model plane could be varied in eight positions 45 degrees apart; the roll could be set at level or 30 degrees either right or left; and the length of exposure of the plane to the subject was limited to one second. The eight graduate gunners who served as subjects in the experiment were given

[7] This experiment was conducted by Lt. Esten W. Ray, with the assistance of Sgt. Alexander N. Levine.

a thorough orientation in the problem and several hours of instruction in its significance. They were taught to refer to each plane aspect in terms of "rad-aspects," i.e., one-rad aspect, two-rad aspect, etc. Training on the apparatus consisted of allowing each subject to make 147 judgments in each of 20 trials over a period of 11 days. The first and last trials were considered test trials on which no knowledge of results was given after each judgment as in the other 18 trials. The trials were given in the morning and afternoon of each of 9 days. Each trial presented the plane in all combinations of pitch, aspect angle, and roll an equal number of times, so that the influence of each position on the accuracy of judging could be determined. After each exposure the subject called out his judgment of whether the plane appeared to be in 0, ½, 1, 1½, 2, 2½, or 3 rad aspects.

TABLE 14.6.—*Learning to judge aspect angles in the laboratory: Mean percent correct judgments by trial. Each trial based on 147 judgments by each of 8 subjects (Laredo, third quarter, 1944)*

Trial [1]	Average percent correct	Trial	Average percent correct
0 (pretest)	43.7	11	70.3
1	49.5	12	70.8
2	55.8	13	70.3
3	61.9	14	76.4
4	62.8	15	72.9
5	64.0	16	73.5
6	68.7	17	75.7
7	68.6	18	76.4
8	69.6	19	74.5
9	67.7	20 (posttest)	76.0
10	72.5		

[1] Knowledge of results not provided on pretest and posttest.

Results: I.—Table 14.6 shows the progress of the group from trial to trial, in terms of the average percent of correct judgments, and table 14.7 shows the average percent of judgments that were correct to within half a rad. It is clear that learning under the conditions of the experiment was rapid and that very few large errors in judgments occurred after the first few trials. It will be noted (trial 0) that, even after a purely verbal contact with the problem, the average subject was able to make about 44 percent correct judgments.

The results for trials 1–14, prior to the attainment of maximum skill, also showed (table 14.8) that as the size of the aspect angle increased, the tendency to err in judging it increased also. Analysis of variance revealed an F ratio of 7.18 between angle variance and error variance with a ratio of 3.05 required for significance at the 1 percent level. The apparent exception to the trend in table 14.8 (the increased average percent correct judgments for 30° angles) is probably due to the fact that errors here were possible in only one direction.

The apparent vertical direction of the fighter's line of motion with relation to the gunner, i.e., upward, level, or downward, appeared to influence the accuracy of judgment of the aspect angle. An analysis of variance for data on inclination of flight presented in table 14.9 produced an F-ratio of 5.04 between position variance and error variance; a ratio of 4.68 was required for significance at the 1 percent level. The data used were for trials 1–14, prior to attainment of top level of skill. Further analysis revealed the difference in variance to be due to the downward position alone. Apparently the aspect angles of planes which presented the gunner a top view were most difficult to judge.

TABLE 14.7.—*Learning to judge aspect angles in the laboratory: Mean percent of judgments correct to within half a rad. Each trial based on 147 judgments by each of 8 subjects (N=8, Laredo, third quarter, 1944)*

Trials [1]	Percent correct judgments (within ±.5 rads)	Trials	Percent correct judgments (within ±.5 rads)
0 (pretest)	85.2	11	98.6
1	93.3	12	98.9
2	95.9	13	99.2
3	96.7	14	99.5
4	96.5	15	99.2
5	96.9	16	99.1
6	97.9	17	99.2
7	98.9	18	99.4
8	98.0	19	99.2
9	98.3	20 (posttest)	98.9
10	99.0		

[1] Knowledge of results not provided on pretest and posttest.

TABLE 14.8.—*Mean percent of correct judgments of aspect angles under laboratory conditions according to size of the angle based on 2,940 judgments by each of 8 subjects (Laredo, third quarter, 1944)*

Angle	*Average percent Correct*
5°	81.7
10°	72.8
15°	61.8
20°	55.2
25°	56.6
30°	67.6

TABLE 14.9.—*Mean percent of correct judgments of aspect angles under laboratory conditions according to inclination of flight and position of roll based on 2940 judgments by each of 8 subjects (Laredo, third quarter, 1944)*

Positions	*Average percent correct*
Position of roll:	
Level	67.8
Upward	67.2
Downward	63.4
Inclination of flight:	
Wings level	65.5
Right wing up	67.5
Left wing up	66.4

The effect of roll, whether right, left, or none, did not appear to influence the percent of correct judgments made, as shown in table 14.9; the data include only trials 1 through 14, prior to attainment of top level of skill. Analysis of variance revealed an F ratio between roll variance and error variance of 1.29; a ratio of 3.03 was required for significance at the 5 percent level.

Conclusions: I. Simulated aspect angles could be recognized.—This experiment suggested strongly that it was possible to train gunners to recognize aspect angles, though it was accepted that the conditions of the experiment were static in nature and gave no indication of the accuracy with which gunners could recognize aspect angles in flight or of their ability to apply proper deflections even knowing the angles.

After the experiment was reported the aspect angle method of determining support fire deflections when using compensating sights was adopted as official Air Force doctrine. In the interest of greater soundness of conclusions and also to provide a basis for planning aspect angle training, a second experiment was conducted to test the ability of gunners in flight to judge the aspect angle of an attacking fighter.[8]

Procedure: II. Judgment of aspect angles in the air.—The experiment was divided into two phases, the first to determine the ability of gunners to differentiate an attack from a support situation, and the second to determine the influence of air and ground training on this differentiating ability. In Phase I, each of eight Martin turret gunners and eight Consolidated tail turret gunners completed six aerial missions evenly divided between two B-24 bombers which flew in parallel courses at the same level with a distance of 40 yards between wing tips. A pursuit pilot made tail cone and quarter attacks on the bombers in accordance with a prearranged schedule; the attacks were randomly distributed between the bombers. The gunners, in their turrets fitted with gun cameras, were required to judge whether it was their bomber or the other one that was under attack and to apply deflection based upon the aspect angle of the fighter, according to instructions which they had received. When a gunner believed his bomber was under attack he pressed his trigger button which caused a small pointer to withdraw from the camera's field of view; presence of the pointer in the developed film indicated that the gunner thought the other bomber to be attacked, i.e., that he was in a support fire situation. The fighter flew a total of 40 attacks on each mission. In assessing the gun camera records, the nature of the attack, the gunner's decisions as to its

[8] This experiment was designed by Maj. John V. McQuitty and conducted and reported by Lt. Daniel J. Histon.

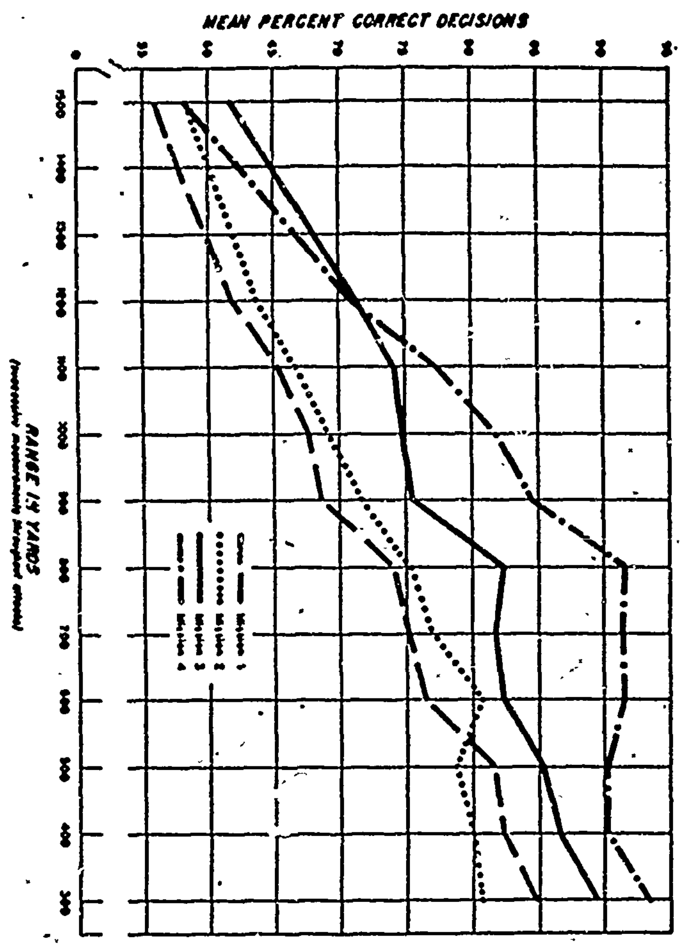

Fig. 14.6 — Differentiation of attack and support situations in flight: Mean percent of correct decisions as to nature of attack, made on each of four missions according to range of fighter plane (B-16, Laredo, 2nd. quarter, '45)

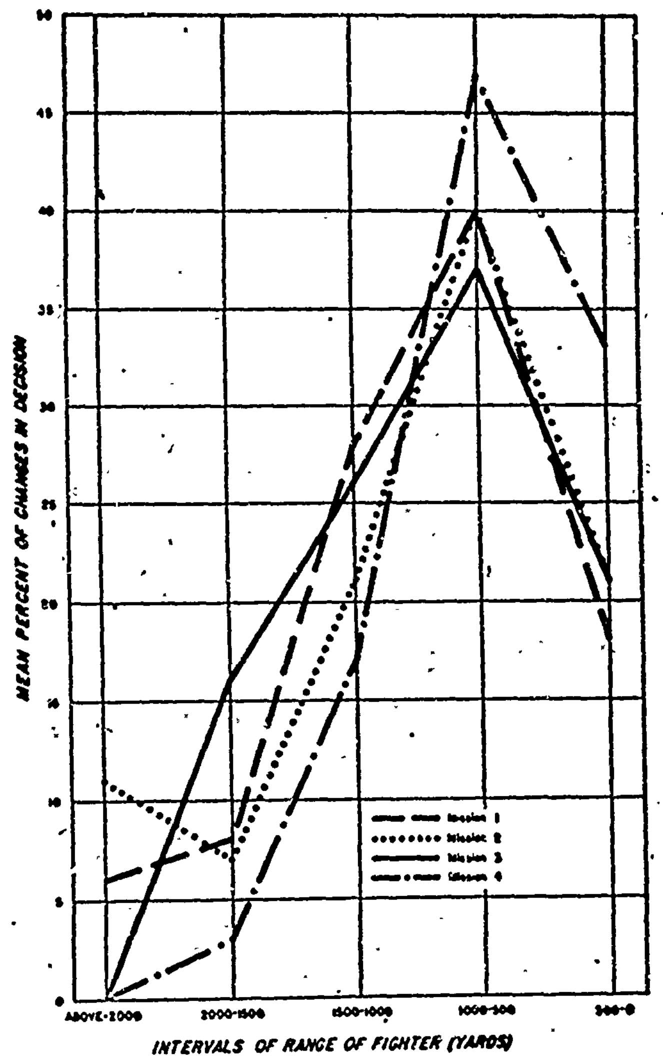

Fig. 14.8 — Differentiation of attack and support situations in flight: mean percent of changes in decision as to nature of attack made on each of four missions according to range of fighter plane (N=18, Laredo, 2nd quarter, '43)

nature, the number of changes in his decision, and the range at which each change of decision took place were recorded. Due to the method of recording the gunner's judgment, a gunner was indicated as deciding in favor of support fire even if he had not yet made up his mind. Therefore, when attack fire was correct, first changes of decision were properly considered as original decisions, since it could not be properly determined if the subject had previously considered the attack as placing him in a support fire situation.

Results: II. The results of the last four missions (the first two were used as familiarization flights) are given in tables 14.10 and 14.11, and are graphically portrayed in figures 14.5 and 14.6.

Insert Figures 14.5 and 14.6

Conclusions: II. Aspect angles could be recognized in the air.—From these data it was concluded that under the conditions of the experiment gunners could distinguish attack situations from support fire situations with reasonable accuracy at ranges which were practical and effective for the application of support fire rules. The accuracy in making such distinctions increased as range decreased. Gunners also appeared to make the differentiation with increased confidence as range decreased, and were less apt to change decisions once made.

Procedure: IIA Additional training on ground and in air.—In Phase II the subjects from Phase I received 2 hours of practice on a static type of ground trainer. The trainer consisted of a model plane mounted so that the aspect angle could be varied from 0 to 30 degrees in increments of 5 degrees, direction could be varied in 8 directions 45 degrees apart, and roll set at level, or 30 degrees right or left. Simulated ranges of 300, 400, 700, and 900 yards were incorporated into the trainer by having the subject stand at appropriate distances from the model plane.

TABLE 14.10.—*Differentiation of attack and support situations in flight: Mean percent of correct decisions at different ranges of the fighter plane for each of four missions (N=16, Laredo, 2d quarter, 1945)*

[PHASE I]

Mission	Range in yards										
	1,500	1,200	1,100	1,000	900	800	700	600	500	400	300
III	55.9	61.8	65.3	67.6	68.6	74.0	75.1	76.3	81.7	82.2	84.6
IV	58.3	63.7	66.5	69.3	71.7	75.2	77.0	80.6	78.8	80.0	80.5
V	61.6	71.3	74.1	74.6	75.4	82.3	81.6	82.3	85.1	86.5	89.4
VI	58.1	71.0	77.4	81.8	84.4	91.5	91.4	91.4	90.1	90.1	93.4
Average	58.5	67.0	70.8	73.3	75.0	80.8	81.3	82.7	83.0	84.7	87.0

TABLE 14.11.—*Differentiation of attack and support situations in flight: Mean percent of changes of decision as to the nature of attack made over the range of the attack. Data reported for each mission (N=16, Laredo, 2d quarter 1945)*

[Number of changes over entire range = 100 percent (Phase I)]

Mission	Range in yards					
	Above 2000	2,000-1,500	1,500-1,000	1,000-500	500-0	Entire range
III	6	8	28	40	18	100
IV	11	7	21	40	21	100
VI	0	16	26	37	21	100
V	0	3	17	47	33	100
Average	4.2	8.5	23.0	41.0	23.3	100

An exposure device limited the subject's view to 1 second. The two parts of the training included angles in a horizontal plane, and those within the 30-degree cone, with approximately 1 hour being given to each part. A preliminary test began each part, followed by three 15 minute trials; the fifth and final period for each part was a test. After each exposure the subject stated his estimate of the aspect angle, and, except in the tests, the experimenter immediately stated the correct angle. If the subject erred he was reshown the model plane and told the correct angle. Following this ground training the subjects flew 4 additional missions under the same conditions as in Phase I.

Results: IIA. The results of the four missions are shown in tables 14.12 and 14.13. In Phase II the percentage of correct decisions was only slightly higher throughout the range of the attacks, although the number of changes in decisions were fewer, and a greater number of decisions were made earlier in the attack.

TABLE 14.12.—*Differentiation of attack and support situations in flight: Mean percent of changes of decisions as to nature of attack made over the range of the attack. Data reported for each of missions VII–X, Phase II (N=16, Laredo, 2d quarter, 1945)*

Mission	Range in yards					Entire range
	Above 2,000	2,000-1,500	1,500-1,000	1,000-500	500-0	
VII	13	12	20	27	28	100
VIII	1	5	28	44	22	100
IX	11	18	47	21	3	100
X	6	7	30	40	17	100
Average	7.8	10.5	31.2	33.0	17.5	100

Conclusions: IIA. Accuracy of judgment of aspect angles did not continue to improve significantly.—The ground training and the continued practice in the air did not produce a trend of improvement in performance through the second four missions. Apparently the ceiling of ability to differentiate support and at-

tack situations under the conditions of this experiment was reached after the fourth training mission. The course of learning throughout the series of eight missions is shown in figures 14.7 and 14.8.

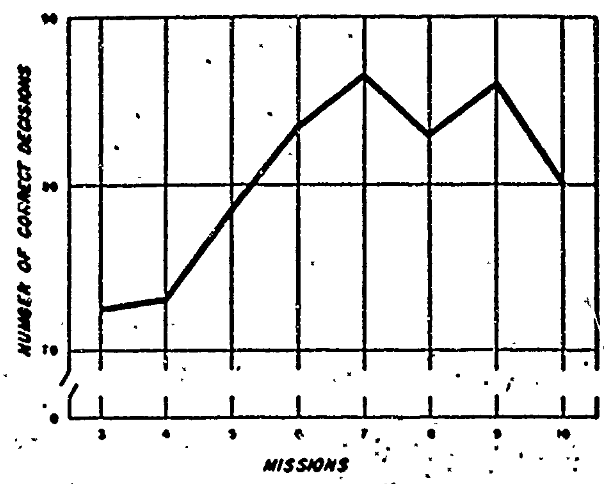

Fig. 14.7—Learning to differentiate attack and support situations in flight: mean percent of correct decisions made by 16 gunners on successive missions. Missions 1 & 2 were orientation missions (Laredo, 2nd quarter, '48)

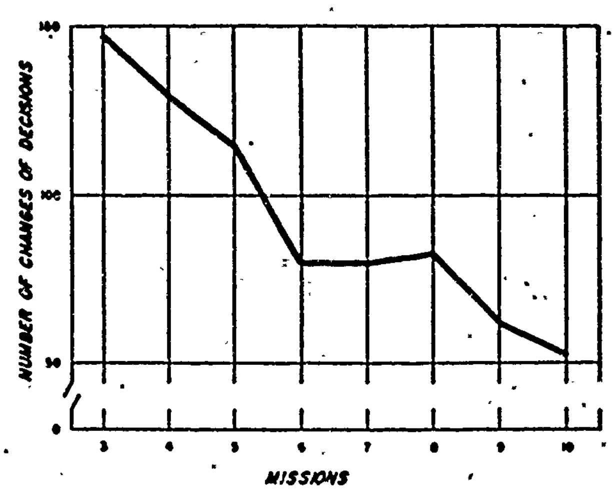

Fig. 14.8 Learning to differentiate attack and support situations in flight: mean number of changes in decision as to nature of attack made by 16 gunners on successive missions. Missions 1 & 2 were orientation missions (Laredo, 2nd quarter, '48)

All of the foregoing seemed to establish fairly well that gunners could be trained to differentiate support and attack situations while in flight.

TABLE 14.13.—*Differentiation of attack and support situations in flight: Mean percent of correct decisions made at different ranges of the fighter plane for each mission in phase II (missions XII–X) (N=16, Laredo, 2nd quarter, 1945)*

Mission	Range in yards													
	1,600	1,500	1,400	1,300	1,200	1,100	1,000	900	800	700	600	500	400	300
VII	75.3	71.8	72.4	72.8	71.2	83.7	86.3	90.7	93.8	93.0	93.0	94.6	94.6	93.0
VIII	61.5	66.7	65.4	63.1	61.3	61.4	65.7	69.7	82.8	89.1	96.6	93.2	95.2	97.3
IX	58.0	58.4	60.4	71.1	71.1	80.0	85.2	92.5	94.8	97.8	97.8	97.0	97.0	98.5
X	58.6	57.6	62.0	64.6	66.3	68.0	78.1	82.7	85.0	87.8	89.7	91.5	91.5	91.5
Average	63.3	63.6	65.1	68.2	67.7	73.3	78.5	83.7	89.1	92.0	94.5	94.1	94.7	95.3

Ability of gunners to lay off support fire deflections.—In order to establish the ability of gunners to lay off proper deflections once aspect angles were determined, the gun camera records from the experiment were analyzed.[9] The gunners had been instructed previously in the amount of deflection to lay off for each aspect angle, and during the missions actually laid off the deflections, using compensating sights (K-13 in the Martin upper and K-10 in the Consolidated tail) with 100 percent of own speed settings. Using the Exact Assessor, a device developed at the fixed gunnery school at Foster Field to assess gun camera film, both aspect angle and the amount of deflection laid off were determined from the exposed film, and the actual deflection was compared with the correct deflection.

The data were reported in terms of absolute deflection errors by mission and in terms of average sighting errors in mils according to aspect angle intervals. The results are summarized in tables 14.14 and 14.15. Comparing the tracking errors reported in table 14.14 for the support situation with those made by gunners

TABLE 14.14.—*Application of support fire deflections: Average absolute deflection errors in mils, by mission. (N=8 for each turret, Laredo, 2d quarter, 1945)*

Mission	Pursuit fire situation								Total
	1	2	3	4	5	6	7	8	
Consolidated turret	5.2	4.0	4.6	3.9	4.0	3.7	3.7	4.2	4.2
Martin turret	3.2	2.9	2.8	4.6	3.0	3.3	3.0	3.0	3.2
	Support fire situation								
Consolidated turret	20	22	30	17	19	18	25	22	21.6
Martin turret	25	25	30	54	27	31	29	20	30.1

tracking pursuit curves with fixed sights as reported in the section of chapter 9 dealing with gun camera, it appeared that the laying off of deflections based on aspect angle judgments was not significantly more difficult than laying off regular Position Firing deflections.[70] Table 14.15 shows how deflection errors varied with the magnitude of the aspect angle; in general, the table shows that algebraic mean errors were positive for angles below 25° and negative for larger angles, indicating that gunners tended to overlead for angles smaller than 25° and underlead for angles greater than 25°. The absolute error tended to be fairly constant for all angles except those in the extremes,

[9] A separate report of this analysis was written by Maj. John V. McQuitty. Technical Sergeant Hyman Kaitz performed the calculations.

TABLE 14.15.—*Application of support fire deflections: Mean algebraic and absolute deflection errors, and absolute directional errors according to size of aspect angle made by 8 gunners in each of Martin and Consolidated turrets. (Laredo, 2d quarter, 1945)*[1]

MARTIN TURRET, EIGHT GUNNERS

	Aspect angle								
	0°–4	5°–9	10°–14	15°–19	20°–24	25°–29	30°–34	35°–39	40° and over
Algebraic deflection error	15.6	19.0	34.3	25.4	7.6	–7.5	–28.7	–31.7	–38.3
Absolute deflection error	17.4	22.6	36.1	30.6	22.2	18.3	30.3	37.2	38.3
Absolute direction error	1.6	2.4	5.3	6.9	7.8	5.6	4.5	4.4	2.5

CONSOLIDATED TURRET, EIGHT GUNNERS

	0°–4	5°–9	10°–14	15°–19	20°–24	25°–29	30°–34	35°–39	40° and over
Algebraic deflection error	4.8	22.6	17.7	14.5	7.4	–3.7	–19.7	–31.2	–47.2
Absolute deflection error	9.2	23.1	22.8	21.9	18.7	19.3	22.9	34.8	47.3
Absolute direction error	3.0	4.1	6.2	6.6	6.6	5.8	5.8	6.9	3.3

[1] Deflection error was obtained by measuring the distance in mils from the correct point of aim to the gunner's point of aim. Errors in advance of the correct point of aim were considered positive; those to the rear negative. Direction error was the distance from the gunner's point of aim to the line of flight of the fighter plane.

and the directional errors appeared to be largely independent of aspect angle.

Table 14.16 shows that sighting errors varied according to range, especially for the Martin gunners; absolute deflection errors remained fairly constant for all except extreme ranges; and direction errors were quite constant for all ranges.

It was concluded that, for the attacks considered in this study, turret guners could lay off deflection according to aspect angle almost as accurately as they could lay off deflections using Position Firing rules. Also it was concluded that the magnitude of the deflection error was relatively constant for aspect angles from 5 to 30 degrees, but smaller for angles less than 5 degrees and larger for angles larger than 35 degrees. Guners showed a strong tendency to overlead in the support situation at short ranges and at ranges greater than 600 yards, a tendency to overlead for angles of 25 degrees or less, and a tendency to underlead for angles greater than 25 degrees.

Possibly unique nature of foregoing studies.—Although the rules for support fire had long been in operational effect before the above results were available, it was demonstrated with

[10] The mean circular error of Martin turret gunners using Position Firing rules against pursuit curve attacks ranged from 19 mils to 25 mils during 10 successive missions of 6 attacks each (see table 9.45).

TABLE 14.16.—*Application of support fire deflections: Mean algebraic and absolute deflection errors, and absolute directional errors according to range, made by 8 gunners in each of Martin and Consolidated turrets (Laredo, 2d quarter, 1945)*

MARTIN TURRET—SUPPORT FIRE, EIGHT GUNNERS

	Range in yards													
	Below 175	175–224	225–274	275–324	325–374	375–424	425–474	475–524	525–574	575–524	625–674	675–724	725–774	775 and over
Algebraic deflection	20	16	20	16	0	0	–2	——	7	7	20	26	27	29
Absolute deflection	20	29	25	21	22	19	24	22	27	27	31	35	32	21
Algebraic direction	–5	–1	1	–2	–2	–2	–2	–1	0	–1	–1	–1	–1	–3
Absolute direction	5	3	4	4	4	4	5	5	6	5	7	6	6	6

CONSOLIDATED TURRET—SUPPORT FIRE, EIGHT GUNNERS

	Below 175	175–224	225–274	275–324	325–374	375–424	425–474	475–524	525–574	575–524	625–674	675–724	725–774	775 and over
Algebraic direction	10	10	11	4	5	0	3	4	3	5	8	10	11	12
Absolute deflection	14	13	21	21	24	20	25	23	21	21	21	22	20	19
Algebraic deflection	–3	–4	–2	–2	–4	–2	–3	–2	–2	–1	–2	–2	–3	–4
Absolute deflection	8	6	5	6	7	6	7	6	6	6	6	6	7	5

MARTIN AND CONSOLIDATED TURRETS COMBINED—SUPPORT FIRE, SIXTEEN GUNNERS

	Below 175	175–224	225–274	275–324	325–374	375–424	425–474	475–524	525–574	575–524	625–674	675–724	725–774	775 and over
Algebraic direction	15	22	22	21	23	20	24	23	24	24	26	30	29	29
Absolute direction	7	5	5	5	5	5	6	6	6	6	7	6	6	6

reasonable accuracy that the procedure adopted was psychologically sound and required no forseeable revision. As far as is known this was the only instance of the psychological implications of an operational procedure being subjected to experimental test for the specific purpose of determining the procedure's adequacy and obtaining information on which to base revisions as necessary.

SUMMARY

The importance of the relationship of the gunner to the equipment he used was largely ignored during most of the war. Several instances of equipment design being unfavorable to effective use of the equipment are cited; for example, the Sperry computing sight in the upper turret of B-17 demanded conflicting manual movements of the gunner while trying to track and frame his target simultaneously. In early 1944 the importance of the gunner-equipment relationship problem was sufficiently clarified in higher headquarters to cause the National Defense Research Committee to establish a special project (NDRC Project AC-94) to investigate the psychological adequacy of the design of gunnery equipment and make recommendations for its improvement.

The suggested operation of an optical illusion similar to the well-known Muller-Lyer illusion in estimating range with iron ring-and-post sights prompted an experiment to measure the effect of the illusion if it existed. Using both iron ring-and-post and optical sight versions of two sight designs, one of which appeared to offer fewer possibilities for the operation of the illusion than the other, a group of subjects systematically made a number of range settings on a Reflectone Range Estimation Trainer. The results indicated that greater errors were made with the sight design suspected of bringing about the optical illusion. The operation of the size constancy phenomenon in the optical sight versions seemed partly to account for the smaller errors in overestimating a standard range which were made with the optical sights.

Although higher headquarters routinely directed the evaluation of training devices before their adoption for general use in the gunnery program, one instance of a directed test of a proposed operational procedure is seen in the case of a three-handled spade grip. This special grip was designed with the idea of facilitating the use of the gunner's dominant eye in lining up the sights with the target. The gunner was to control the gun with the hand corresponding to his dominant eye on a third handle located between the two regular handles and a little farther behind the

gun. A group of gunners equally divided as to eye dominance fired according to the recommended plan on a moving target range. The results indicated no reliable difference in favor of either the standard or the three-handled grip.

In the remotely controlled gunnery system of the B-29 the vibration of the sight did not preclude the photographing of combat gunnery as it had with all previous types of sights. A weight to counter-balance the weight of the gun camera was designed and produced for general use in training and combat. Although the difference in "feel" between the standard sight and the sight equipped with camera and counter-balance seemed to be very small, it was believed advisable experimentally to determine if the use of the counter-balanced gun camera would detrimentally influence the gunner's sighting accuracy. A group of subjects practiced sighting on a trainer alternately equipped with a regular sight and one with a camera and counter-balance attached. The results showed only slight differences in performance in favor of the regular sight, and not all of these appeared to be reliable.

The activities of psychologists in the field of operational gunnery theory and technique included furnishing advice based on their professional background. It was recommended that the range for opening fire on the high-speed frontal attacks against B-29's be extended to take into consideration the time required for the gunner to determine the range of the fighter and open fire, thus allowing a maximum of time for the guns to be firing while the target was within the effective range of the guns. When the Position Firing system of sighting became the official defensive fire doctrine for bombers, psychologists assisted in planning the new training courses, and made recommendations as to how the operation of the system should be interpreted to gunnery students.

A simplified method for using iron ring-and-post sights was recommended partly because the older (eye-base) method required that the gunner keep his eyes a constant distance from the sight and appeared to be therefore much more subject to error during the excitement of combat; additionally, there were some experimental data which suggested the superiority of the newer method.

An instance of the psychological implications of an operational procedure being subjected to experimental test for the specific purpose of determining the procedure's adequacy and recommending revisions as necessary is seen in the studies of the application of support fire rules. In order for a gunner with a compensating sight to aim effectively at a fighter plane attacking another bomber in his formation, it was necessary for the gunner to estimate

what was termed the "aspect angle" of the fighter. The task of recognizing a support fire situation and of applying appropriate deflections appeared to be difficult. Experiments were conducted which indicated that it was possible not only for gunners to differentiate between support fire situations and direct attack situations, but also that when using compensating sights in a support fire situation it was possible to apply deflections which were not significantly less accurate than deflections laid off by gunners with fixed sights against pursuit curve attacks on their own bombers.

CHAPTER FIFTEEN

Psychological Research on Flexible Gunnery Training: Summary and Critical Evaluation

Maj. NICHOLAS HOBBS

This summary is provided to assist the reader in obtaining an overview of the work which is treated in detail in the body of the report. An effort has been made to make the summary sufficiently complete to satisfy the reader who wants enough detail to know what was done, what was learned, and what the significance of the work seemed to be, but who does not care to study each chapter. A satisfactory balance between a general account and a specific discussion has been sought.

In this final chapter, there are also observations of a general nature about the work of psychologists in gunnery. The war ended with a number of technical developments in air warfare that make the future of flexible gunnnery uncertain. Radar, jet-propelled fighters and bombers, guided missiles, and proximity fuses reduce many of the specific findings reported here to matters of historical interest. Techniques developed or given new application may fare better, for they may be useful in various research programs. Perhaps most significant of all will be some of the generalizations which may be made about the functioning of psychologists in a cooperative research program involving many types of specialists. These generalizations will be advanced as hypotheses which may be usable by other research groups.

SUMMARY

Brief History of Flexible Gunnery

Although the bombers of World War I mounted flexible guns for defensive purposes, there was little progress made in the development of flexible gunnery equipment or theory prior to the second World War. During this period there was almost no

flexible gunnery training. The training of gunners in the Army Air Forces on a large scale began in December of 1941, when the first gunnery school was opened. The training program grew rapidly until there were seven basic gunnery schools in operation, each graduating from 400 to 500 gunners each week. The early training programs for these men consisted of a varied assortment of courses, ranges, and trainers quickly developed to meet an urgent need. The development had to proceed rapidly without the benefit of an accumulated body of experience, and the training given to gunners fell short of the demands of combat organizations to which gunners were assigned. Enemy opposition against AAF bombers, particularly in the European Theater, was determined and effective, resulting in bomber losses that were considered to be serious. The introduction of fighter escort aided considerably in reducing bomber losses, but there was still a need to improve the effectiveness of flexible gunnery.

The establishment of the AAF Instructors School (Flexible Gunnery) in December of 1942 was an important step in the direction of better gunnery. The primary objective of this school was to train instructors, but it was also charged with the standardization of gunnery training, with preparing training materials, and with research. Research in gunnery was started by psychologists who were exploring means of selecting men for gunnery training. After preliminary studies were made at three gunnery schools, Psychological Research Detachment (Gunnery) was activated, in March 1943, to continue the work and also to study problems of training. The Detachment worked closely with the Instructors School. In the year following the activation of the Instructors School, many advances were made in gunnery training. Several synthetic trainers were put into general use; combat-type aircraft were made available for use in training; standard examinations were adopted for use in all schools; a new type of performance test, known as a phase check, was developed; a fairly adequate sighting system was adopted; the Gunner's Information File was published; and several improvements were made in sighting equipment.

The next major development in gunnery occurred in May of 1944 when the Central School for Flexible Gunnery was activated and all gunnery training brought under the supervision of one special staff office at Headquarters, AAF Training Command. The organization of the Central School provided for the training of enlisted instructors and of gunnery officers, for liaison among all gunnery training agencies, and for an expanded program of research. Most of the research and development work in gunnery was made the responsibility of the Research Division of the

kept the problem from being hopeless of solution. Bomber and fighter courses were not erratic. Bombers typically flew straight and level, with little fluctuation in speed. And though fighters were more maneuverable, they had to commit themselves to a definite course if they were to get an appreciable number of hits on bombers. The guns on fighters were normally fixed to fire forward and were aimed by aiming the fighter. For the guns to remain pointed toward a moving bomber, the fighter had to be flown on a predictable course, called a "pursuit curve."[1] To a gunner in the bomber the attacking fighter appeared sensibly head-on and seemed to grow larger and to swing towards the tail of his bomber, until the attack was broken off.

Several types of sights were used to help the gunner predict where the fighter would be by the time the gunner's bullets reached their target. Simple ring sights, graduated in "rads" (rings of a standard radius), required that the gunner estimate a lead, or "deflection," according to the position of the attacking fighter off the beam of the bomber. Deflections were large (3 rads) for a fighter dead abeam (at 90° "angle off") and decreased to zero for a fighter dead ahead or dead astern. "Compensating sights" mechanically set in the appropriate rads deflection for the gunner, who was required to keep the center of his sight on the nose of the attacking fighter. A third type of sight, known as a "computing sight," required the gunner to track the target and at the same time to frame the target within two variable vertical lines or within a variable circle by operating hand or foot controls. Computing sights multiplied the angular travel of the target (supplied by tracking rate) by the range of the target (supplied by framing) to predict the point of collision between the gunner's bullets and the fighter. The operation of all types of sights and gun positions required considerable skill.

In addition to using his equipment, the gunner had to clean it, make minor adjustments, and detect faulty operation. He also had to be able to use certain auxiliary equipment, such as the interphone, heated clothing, and oxygen equipment. As a member of a crew, he had to be proficient in sundry skills, such as procedures for emergencies.

The Gunner

The men who were expected to perform the job outlined above

[1] A small model of a bomber and of a fighter can be used to illustrate the pursuit curve clearly. Place the fighter off the beam of the bomber and pointing towards the bomber. Tie a string from the nose of the fighter to the nose of the bomber. This represents the trajectory of the fighter's bullets. Move the bomber forward and slowly shorten the string. The fighter will move closer to the bomber and will swing towards the path of the bomber, simulating a pursuit curve.

were drawn from the middle of the distribution of the Air Forces population, in terms of ability. They were inferior to aviation cadets but they were superior to general duty enlisted men. There was, of course, much overlapping, but these statements give the correct general picture. Army General Classification Test scores of gunners consistently averaged around 111, from class to class. Mechanical Aptitude Test scores ranged around 106. These scores were several points higher than those for enlisted men in the Army at large. Gunners were somewhat better educated than the civilian population. The mean educational level was 3 years of high school, but the modal level was high school graduate. In age, gunners ranged from 18 to 37, with the mean for one group studied falling at 23.5 years. Most gunners had been out of school for several years before entering gunnery training. Gunners were not systematically selected for training until near the end of the war when it became administratively possible to select B-29 gunners. There were 2 stages of training for gunners prior to combat: individual training for 6 weeks in a basic gunnery school of the AAF Training Command, and crew training for 12 weeks in 1 of the 4 training air forces. The effectiveness of this training and the effectiveness of gunners in combat were considered by competent observers to be lowered by generally inadequate motivation of gunners. Lowered motivation was attributed to the inferior status of gunners in the Air Forces and to the nature of the gunner's job which provided the individual gunner with no dependable indication of his ability to score hits.

Psychologists in Flexible Gunnery Research

Psychologists in gunnery studied the gunner's job and the gunner, with the objective of improving the combat effectiveness of gunnery. There were four stages in the development of psychological research:

(1) *Early Research Detachments.*—In the latter part of 1942, psychological research detachments were sent to three basic gunnery schools for the purpose of assisting in the selection of low-altitude bombardiers from among graduates of the schools. A secondary purpose of these detachments was to explore possibilities of developing a battery of tests for the selection of gunners. This work was terminated in December of 1942.

(2) *Psychological Research Detachment (Gunnery).*—The original research detachments stimulated interest in psychological research in gunnery, and a request was made that the work be continued. To this end, Psychological Research Detachment (Gunnery) was activated in March 1943, to work in close conjunction with the Instructors School.

(3) *Psychological Research Unit No. 11.*—The work of the gunnery detachment expanded, and a larger and more permanent organization was requested by gunnery training personnel. Psychological Research Unit No. 11 was therefore activated in October 1943. The mission of this unit was defined in general terms as follows: "To conduct research on psychological aspects of problems having to do with the effectiveness of flexible gunnery training methods and increasing efficiency of the performance of the gunner." Though selection problems remained important, emphasis was also placed on problems of training.

(4) *The Research Division.*—Other specialists, such as mathematicians, physicists, engineers, writers, artists, and gunnery experts, were added to the staff of the Central School to assist in improving training. All technical personnel, including psychologists, were finally grouped into one agency known as the Research Division. This grew into a large cooperative research organization which was largely responsible for the detailed planning of gunnery training. Psychologists staffed several of the sections of the Division and were prominent in its over-all operation.

Two features of this development are noteworthy. First, psychologists in gunnery worked very closely with training personnel on training problems. Second, psychologists worked in cooperation with other technical specialists. Such cooperative research may well prove more rewarding than research by specialists organized into separate groups according to their fields. Experience in this approach to gunnery problems suggests that in research concerned with the improvement of the operating efficiency of men or with improving the design of the equipment with which they work, psychologists may well serve to integrate the work and to give it fruitful orientation.

The Nature of Gunnery Proficiency

Accurate and detailed descriptions of the duties of gunners in combat were required for developing selection and training procedures, and for arriving at a criterion by which selection and training procedures could be validated. The two problems were distinct, though closely related. Plans for selection and training had to be developed whether an adequate criterion was available or not, but no systematic improvement could be made in selection and training procedures without a criterion which would make possible the experimental evaluation of various possible procedures.

The most useful descriptions of the job of the gunner were

made by observation of gunnery in combat zones. Such studies involved questioning gunners and gunnery officers, examining mission reports, attending "briefings" and "critiques" of combat missions, observing gunners doing each of their combat jobs, and flying missions as a gunner. One study that employed all of these techniques resulted in a precise statement of what B-29 gunners had to know and be able to do. The list was complete and inclusive. The single most important task of the B-29 gunner was "to track and frame smoothly and accurately with his specialized sight." This emphasis was immediately reflected by changes made in the training program for B-29 gunners. Other items indicated that B-29 gunners had to be able "to trigger correctly, use standard interphone procedure, search properly, load the guns in his assigned turret, clear his guns," and so on. The important consideration was that these items were specifically defined and that the list was complete. A training program based on the requirements stated would meet all of the requirements of the air force to which the gunners were to be assigned.

For purposes of planning selection procedures, an analysis of the aptitudes required to perform combat duties was more useful than straight job descriptions. Analyses of this type were done, using uniform procedures, in four theaters of operation. Combat gunnery officers were asked to indicate the degree to which gunners should possess certain characteristics stated and defined in a checklist. Gunnery officers considered the qualities of emotional control and motivation to be most important, with speed of decision and reaction, division of attention, dependability, coordination, mechanical comprehension, and memory as of high importance. Mathematical skill was considered least important of all qualities listed. It is interesting to note that the intercorrelations among judgments of gunnery officers in four different theaters ranged from 0.87 to 0.94. The results of these studies were used in developing selection tests and in weighing tests in selection batteries.

Experimentation to improve training and selection procedures required an adequate criterion of gunnery proficiency. A measure of the ability of gunners to shoot down enemy planes would be the ideal criterion. However, numerous factors made it unlikely that a criterion could be obtained from the performance of gunners in combat. Some substitute criterion was therefore sought in the training program. Success and failure in training were first examined as a possible criterion, but investigations of the elimination policies of the basic gunnery schools revealed that few men were eliminated (seldom as many as 10 percent of a class) and that the reasons for elimination varied from school

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to school and even from class to class. Attention was turned to the possibility of obtaining multiple criteria which were reasonably valid, reasonably reliable, and obtainable with a reasonable amount of effort. Standardized achievement tests developed centrally and used uniformly by all gunnery schools provided a dependable measure of knowledge of gunnery. Phase checks, which will be described presently, provided adequate measures of ability to care for gunnery equipment. These were ancillary tasks, however, and there remained a need for a criterion of the ability of the gunner to aim and fire his guns. Several synthetic trainers, notably the Waller Trainer, the Jam-Handy Trainer, and the Hobson-Strnad Trainer, provided fairly satisfactory measures of proficiency in aiming and tracking. Ground ranges added the actual shooting of guns to the performance, but the aiming requirements of ground range firing were quite unrealistic, except for the Poorman Range, which was not widely used. Air training added apparent validity by requiring gunners to shoot from bombers at aerial targets. Firing at towed flag or sleeve targets was unsatisfactory because aiming was unrealistic. Gun camera exercises met all requirements for aiming and tracking but did not include practice in firing the guns. The Frangible Bullet Trainer, an armored fighter at which gunners could fire caliber .30 projectiles which would disintegrate harmlessly on impact, presented a somewhat distorted aiming problem and yielded such a small proportion of hits that scores obtained were not reliable. The Firing Error Indicator, a device which could be mounted in a glider and towed in a realistic attack pattern, provided, by means of radio signals, a rough indication of the distance and direction in which projectiles missed the target. Although the most promising of all aerial targets, the Firing Error Indicator was not fully developed at the end of the war. All things considered, the gun camera provided the most satisfactory criterion of the gunner's ability to use his equipment in a manner that might be expected to result in hits on fighters in combat.

The Selection of Gunners

Problems centering around the selection of gunners may best be summarized from two viewpoints, one pertaining to the technical job of developing tests which would predict success in gunnery and the other pertaining to matters of policy.

Early attempts at developing a battery of aptitude tests which would identify those men who were most likely to achieve a satisfactory level of proficiency as gunners were limited by the inadequacies of the criteria available for the validation of tests. It was not until late in the war that criteria were developed which

were reasonably adequate. However, a number of studies of the validity of tests were done over a period of 3 years, using the best available criteria. The general picture presented by the results of these studies is as follows.

Academic proficiency as measured by reliable achievement tests could be satisfactorily predicted. Correlations of from 0.40 to 0.50 were representative. A median r of 0.45 was obtained for the composite score on 10 classifications tests. The Aptitude Test for Aerial Gunners, AC30A, yielded a correlation of 0.49. A battery of tests which included the Army General Classification Test and the Mechanical Aptitude Test correlated with academic grades of three classes in each of 3 gunnery schools, the coefficients being 0.55, 0.66, and 0.44; the AGCT and MA yielded multiple r's of 0.49, 0.49, and 0.36 for the same groups. The pilot stanine correlated 0.53 with the gunnery final examination for one group studied, with the bombardier stanine having a coefficient of 0.47, and the navigator stanine a coefficient of 0.25. Specific tests which appeared most closely related to academic success were Technical Vocabulary, CE505C, Mathematics, C1708A, Mechanical Principles, C1903A, Reading Comprehension, C1614G, and the Army General Classification Test. Proficiency in aiming and firing guns was predictable with less efficiency. Correlations between various tests and ground-to-ground and air-to-air firing were low, typically of the magnitude of 0.05 to 0.20. However, the validity of these criteria was considered to be low also. Gun camera scores provided a more satisfactory criterion from the standpoint of validity. Among the various tests tried out for predicting this criterion, the Two-Hand Pursuit Test (Thurstone), CM801A, appeared to be the most promising, yielding validity coefficients greater than 0.40 both for a group of 32 Martin gunners and for a group of 32 Sperry gunners. In one study conducted in 1942, biserial coefficients were obtained between the composite score on 10 selected tests and the criterion of pass-fail in gunnery training. For two schools, the r's were 0.44 and 0.53. It seems reasonable to conclude that tests could have been used to send into gunnery training men of greater promise than those who were actually accepted for training.

Critical considerations in formulating policy with reference to the selection of gunners were two: the number of gunners to be trained was large (during one year some 3,000 gunners were trained each week), and no one could define adequately what minimum levels of aptitude were required of gunners. The first factor meant that nearly all men who could meet minimum physical and mental requirements but who could not qualify for or succeed in aviation cadet training were trained to be gunners.

Though many gunners were tested, an effective selection program was precluded. A brief respite was gained from the mass training of unselected gunners in 1945 when the B-29 gunnery training program was getting under way. It became possible then to divert the best qualified men to this type of training. However, had the war continued, nearly all gunners would probably have been trained for the B-29, and the selection program most likely would have reverted to its former ineffectiveness. It is believed, however, that more careful planning would have made a selection program feasible. It is possible that many more gunners were trained than were needed for combat, or for instructional staffs. Men trained as gunners were frequently used for jobs not closely related to gunnery, such as truck driving. Had the requirements for numbers of gunners been more precisely defined, and thus reduced, better men could have been selected for gunnery training. On the other hand, had the requirements for skills of gunners been more precisely defined, more effective demands could have been made for a gunnery selection program. It is probable that these types of training which can define their requirements with precision, and do so convincingly, are more likely to have their requirements favorably considered. Unfortunately, the flexible gunnery program was not able to specify what minimum aptitudes or skills were necessary to ensure an increase in the number of enemy fighters shot down.

An hypothesis which may be useful in future gunnery programs grows out of the relationship between selection and training. Since the selection of gunners appeared administratively unfeasible, research in gunnery was concentrated on improving training procedures. Towards the end of the war, however, some evidence was obtained from training research which emphasized the importance of selection. Studies of gun camera performance showed relatively little learning as a result of practice but revealed fairly stable individual differences in proficiency. It is possible that the final level of proficiency could have been raised more readily by eliminating men of less aptitude than by extending the training of the total group.

The Development of Achievement Tests

A remembered question from one of the early gunery achievement tests was a combination completion and true-false type item. It read, "The .... is the Army's fastest twin-engine bomber. True............ False............" Not all items were as bad as this one, but the tests generally left much to be desired. They were hastily constructed, sampled only small portions of the subject matter taught, and were administered in such a manner as to

assure that nearly all students passed. Efforts to standardize gunnery training were accompanied by efforts to improve testing procedures. At first, emphasis was placed upon training instructors properly to develop and administer achievement tests. A manual was prepared and courses were introduced in the Instructors School, both emphasizing the desirability of objectivity in testing, of adequate course coverage, and of clarity in writing items. Instruction was also given on how to administer and score examinations. Later, with the increase in the number of psychologists in gunnery research, the function of test construction was taken over by the Psychological Research Unit. Thus centrally constructed standard tests were made available to all gunnery schools. Emphasis on the indoctrination of instructors was shifted to procedures for the administration of tests and to the use of tests to improve instruction.

Improvement in instruction through the use of test results was accomplished by means of the Error Item Analysis Report Form. For each item in a test, there was on the form a brief description of the content of the item, followed by a reference to appropriate lesson plans and to sections in the Gunner's Information File pertaining to the item. The tests were commonly given by an examining section, which tallied on the Error Analysis Report Form the number of students missing each item. This made it possible to furnish each department head and each instructor with a weekly summary of the areas of weakness of students in their departments or classes.

In time, the use of a standard final comprehensive examination in all gunnery schools was directed. This examination consisted of from 135 to 150 multiple-choice items. The first and major part of the test-sampled items on general gunnery materials; the second and smaller part was divided into sections, each section pertaining to a specific turret. All gunners took the first part of the examination and then selected the section in the second part which pertained to the turret on which they had been trained. The examinations were printed in loose-leaf format, and separate answer sheets, which could be machine scored, were provided. A noteworthy feature of the gunnery achievement tests was the liberal use of pictorial items, which reduced to a minimum the demands for verbal facility.

Most of the work on achievement testing was devoted to the development of the Gunnery Final Examination. There were four major editions of this test, the first and last two editions having equivalent forms. The items for the examination were based upon training manuals, lesson plans, technical orders, and similar materials. Care was taken to write each item as clearly

as possible and to make all of the alternative responses useful. Homogeneity within the subtests, such as weapons, sighting, and aircraft recognition, was sought through internal consistency item analyses. Effort was also directed toward obtaining maximum total test reliability. The reliability of the successive editions of the test ranged from 0.73 to 0.88, the latter forms having the higher reliability coefficients.

The gunnery school final examinations were used as one basis for the elimination of deficient students from training, as one basis for the selection of instructors and gunnery officers, and as a criterion in several research studies. They seemed to provide additional motivation for students, and they served as useful tools for detecting weaknesses in instruction.

Phase Checks

Because of lack of equipment and lack of experience in the training of gunners, early gunnery training tended to be highly verbal. Gunners became skilled in talking about gunnery and in passing written examinations about gunnery. To shift the emphasis in training from verbal learning to learning by doing, gunnery performance tests, known as phase checks, were developed. A phase check consisted of a series of carefully-prepared items which described precisely each step in the performance of some gunnery task, such as stripping and assembling the caliber .50 machine gun. Instructors, known as phase checkers, used the list to check the gunner on his ability to demonstrate that he could perform each of the steps in the given task. Since all important steps in the task were covered, it was possible to use phase checks for training as well as for testing. Thus training, testing, and the final combat job in care of equipment could all be made similar if not identical. Phase checks were developed for the caliber .50 machine gun, for all turrets, and for all preflight, inflight, and postflight procedures. They measured proficiency in all of the important duties that a gunner had to perform to ready himself to aim and fire his guns.

Through experience in developing many phase checks, certain principles were worked out for their construction. Initially, it must be determined that the task is uniformly accomplished, or at least that it can be made uniform by training. The performance involved must also be observable, or there must be some product of the performance which can be checked for adequacy. With these conditions met, items can be prepared. In preparation of items, it was found that clarity of wording, discreteness of each step, order of steps, scorability of the individual item, and closeness to the requirements of the task in combat were the

most important considerations. Having prepared and assembled items, it was found that careful attention to the preparation of directions to the phase checker, and of directions for the phase checker to read to the student, was rewarding, for uniform administration was requisite to reliable scoring. The scoring of phase checks presented several problems. It was found best to score each item on an all-or-none basis, checking steps correctly done, and marking with a zero steps incorrectly done. Final raw scores were obtained by counting the number of errors indicated. All attempts to work out a system of weighting of items, either on the basis of judgment of their relative importance or by statistical analysis, failed. For convenience in comparing students on various checks, raw scores were converted to scores on a normalized 5-point scale. Converted scores were obtained on subparts of a phase check for diagnostic purposes in training, as well as on the total check. For operations where speed was an important consideration, converted scores were derived from raw error and time scores combined.

The validity and reliability of phase checks were not readily determined by usual techniques. The validity of a phase check was inherent in the instrument itself, since the check required the performance of every step in a particular task required of a gunner in combat. One statistical estimate of reliability of phase checks yielded a coefficient of 0.65. However, little confidence could be placed in this estimate because of the small proportion of errors to the total number of items on the check. The problem of determining reliability statistically was neglected in favor of improving the accuracy and usability of a technique that was so obviously valuable in gunnery training. Towards the end of the war, training reached a level of proficiency that produced gunners nearly all of whom attained perfect or near perfect scores on all phase checks.

Phase checks were widely used as tests, as training devices, and as criteria in research studies. Their significance in gunnery training is suggested by the quantities used. The printing of one series of phase checks ran to 1½ million booklets and about 9 million answer sheets. Their use was directed in all basic schools, in all gunnery training stations of the training air forces, and in most combat air forces. Phase checks similar to those developed in gunnery were developed for bombardier training in the Army Air Forces and for gunnery training in the Royal Air Force. It is judged that phase checks could be developed and profitably used in comparable civilian training programs.

The Evaluation of Training Devices and Procedures

A continuing concern of the Research Division was the evaluation of training devices and procedures that were used or proposed for use in gunnery training. In many respects, this was one of the most important functions of research, for the nature of gunnery tended to favor the development of numerous devices and procedures to substitute for the unattained realistic training situation in which the gunner could practice the skills required of him in combat. Some screening was necessary to ensure that the most effective substitute devices were used, and that the devices which were adopted were used in the most efficient manner.

A number of devices were developed for teaching gunners to range and track. An early sighting system was based upon the accurate estimation of range, from which estimates of required deflection could be calculated. The Reflectone Trainer was used to give instruction in range estimation. Gunners were required to estimate the apparent range of a model airplane inclosed in a long box, the range being mechanically variable by the adjustment of the relative position of mirrors reflecting the image of the model plane. Under classroom conditions, it was found that gunners learned little on the trainer after about 150 settings of the apparatus, and that most learning occurred during the first 30 settings. The findings were corroborated by a laboratory experiment. On the basis of these investigations, it was possible to recommend the elimination from the curriculum of about 8 hours that had formerly been devoted to this trainer. Under classroom conditions, reliabilities fluctuated around 0.75. Observation indicated that most subjects quickly learned to use extraneous cues to estimate "range," cues which would not be available from a bomber in flight.

The Reflectone Trainer was later dropped from the curriculum. An outdoor range estimation range was substituted, but a decrease in emphasis on range estimation in sighting resulted in converting the outdoor range into a tracking trainer. Gunners operating turrets mounted on stands would track and frame a fighter which would sweep low over the positions. Performance was recorded on gun camera film. Because only a small amount of film was available for use on the outdoor trainer, and because much of the film that was used was improperly exposed under normal training conditions, the reliabilities of student scores obtained were so low (in the neighborhood of 0.50) that it was recommended that the range not be used for making comparisons among students unless more favorable training procedures could be developed.

A somewhat more satisfactory device was the RCAF Range Estimation Trainer. This device required the gunner to estimate the range of fighters presented by moving picture film. Experimental evaluation indicated that gunners learned quickly to estimate the amount of their ring sights which was filled by the fighters at various ranges. It was recommended that this device be used.

To provide practice in tracking and framing, a device known as the E–8 Spotlight Trainer was used. Gunners were required to track a spot of light which followed an irregular course around a semispherical screen. If the gunner were operating Sperry equipment, he was also required to frame the spot of light, which would expand and contract in a fashion that roughly simulated the increase and decrease in apparent size of an airplane as its range changed. Scores were obtained through a photoelectric counter system. Under classroom conditions, reliabilities of about 0.40 were obtained, and it was recommended that the device not be used to differentiate among students on ability to track and frame. It was demonstrated, however, that learning did take place on the trainer, and its use in the program was continued. A study to measure the influence that practice on the Spotlight Trainer would have on gun camera performance indicated some improvement of ability to track, using Sperry equipment, even though the reliabilities on the trainer remained low.

To train B–29 gunners to track and frame, an outdoor range, equipped with B–29 sighting stations arranged in a pattern somewhat similar to the location of the sighting stations in a B–29 airplane, was employed. Fighters flew over the turrets, students tracked and framed the fighters, and performance was recorded by means of gun cameras mounted on the sights. A brief study indicated that satisfactory learning was evident in this practice. No studies of reliability or of validity were undertaken.

Ability to track an unseen fighter by use of radar equipment became important in the training of tail gunners for the B–29. A device, known as the AN/APG–15 T1 Trainer, was used to train gunners in the necessary skills. In using the trainer, gunners would manipulate their sighting equipment to track a spot of light which appeared on a radar scope and followed a path similar to that generated by an attacking night fighter. Scores, which were obtained from electrical error integrator units, were satisfactorily reliable, ranging around 0.85. A study of the obtained learning curves made it possible to recommend that approximately 11 trials of 8 minutes each be given to radar gunners.

The trainers described above all required that the gunner follow

a target with the target centered in the sight, and sometimes with the additional requirement of adjusting the reticles of the sight so that the target was framed. Deflection trainers required a somewhat more complex performance in that the gunner had to estimate and lay on a deflection and to change this deflection during the course of an attack. One trainer used to develop skill in deflection tracking was the Waller Trainer. This was an elaborate device, which used five synchronized projectors to picture on a very large curved screen the attacks of actual fighters, which had been photographed by five synchronized cameras from a bomber in flight. The gunner operated hand-held or turret-mounted guns, and a score was mechanically obtained for rounds fired, bursts fired, and hits scored. Several studies of this trainer were performed. Under classroom conditions, reliability of scores tended to be low, but it was demonstrated that reliabilities as high as 0.80 could be obtained when scores from 8 tests given under controlled conditions were combined. Considerable learning, which extended over quite a number of trials, was evident. When practicing, gunners could obtain immediately knowledge of the accuracy of their firing by an auditory signal received through interphone equipment. One experiment indicated that gunners receiving this signal during practice were consistently superior in performance to those gunners who did not have the advantage of the signal.

The Jam-Handy (E–14) Trainer was similar in principle to the Waller Trainer, though much simpler in design. There were two synchronized projectors, one presenting on a small flat screen the view of an attacking fighter, and the other presenting the correct point of aim for the attack. For testing purposes, the gunner wore polaroid glasses which made it impossible for him to see the polarized light from the superimposed ring sight, although the ring sight remained visible to the instructor. The gunner's point of aim was indicated by a pin point of light projected from his simulated gun. Scoring was accomplished by the instructor who recorded graphically the gunner's initial point of aim with reference to the correct point of aim, and measured the amount of error in standard units. Though the scoring was subjective, reliabilities in the 0.80's were obtained when trained instructors were used.

Two modifications were made in the Jam-Handy Trainer to provide a mechanical scoring system. One of these employed a photoelectric cell which was activated by infrared light reflected from the correct point of aim when the gunner was correctly pointing his guns. This system was sound in principle but had flaws in design which were not eliminated early enough to make

the device usable. Another modification employed mechanical linkages to permit matching the gun position with the position of the target, giving a score based on a photocell counter. This latter modification yielded reliabilities which ranged from 0.73 to 0.82, and its adoption was recommended.

For the training of B-29 gunners, several Jam-Handy Trainers were installed in a large room with the sighting stations in the same relative position as they were on the B-29. An evaluation of this trainer showed learning and adequately reliable scores. It was recommended that the device be considered for use in training. Useful information was obtained from this study relative to incidence of fatigue among several well-motivated subjects.

The DeVry Panoramic Trainer was comparable to the Jam-Handy Trainer, except that the target was presented on two small, ground glass screens enclosed in a box into which the gunner looked, an arrangement which made a darkened projection room unnecessary. The DeVry was equipped with an electronic scoring system indicating the number of rounds fired and the number of hits obtained. Adequate evidence for learning on the trainer was obtained, but there was no evidence that practice on the DeVry would transfer to performance on either the Jam-Handy Trainer or gun camera exercises.

The shotgun was ubiquitous in gunnery training. It first was used on the skeet range, a range which was subsequently modified in sundry fashions to make the training appear plausible. Scores obtained on the skeet range were quite reliable (above 0.80 consistently), and a small amount of learning occurred. With the introduction of a rational system of sighting, known as Position Firing, skeet gave way to the Basic Deflection Range, which required the gunner to use aiming rules roughly similar to Position Firing rules. Another modification of skeet called for the firing of a post-mounted shotgun from a truck which circled a track at about 20 miles per hour. Clay pigeons were the targets. The reliability of scores on the Basic Deflection Range was around 0.85 and on the Moving Base Range around 0.90 (for 10 trials). Seven trials of 25 rounds each did not seem to exhaust learning on the Basic Deflection Range, and learning continued on the Moving Base Range after the twelfth trial. The effect of removing either of these ranges from gunnery training was not evident in the performance of gunners on gun camera exercises, in one study. To provide practice in turret manipulation, shotguns were mounted in training turrets and fired at clay birds ejected from a platform mounted on a tower about 30 feet high. Six trials of 25 rounds each gave an estimated reliability of 0.67, with the reliability of the last three trials being 0.72. Most

learning seemed to occur during the first few trials. Finally, skeet was modified once again into what was called the Giant Skeet Range, which permitted a longer period of tracking for each shot. Reliabilities were again good, learning occurred, but there was no indication that practice would transfer to performance in the DeVry Trainer, which also required the application of Position Firing rules.

The gunner was introduced to his weapon on the machine gun ranges. Though all machine gun ranges had certain artificialities which reduced their value as trainers of sighting skills, they did familiarize the gunner with guns he would use in combat, which was considered valuable. On the Moving Target Range, gunners fired either hand-held or turret-mounted guns at a square cloth target which was towed across the line of fire, at ranges from 200 to 400 yards. The sighting problem was unlike that in the aerial situation, and tracking was limited to the horizontal plane. The reliability of scores obtained on this range varied typically from 0.50 to 0.70. No data on learning are available.

On the Burst Control Range, the target was moved in to a distance of 1,000 inches from the gunner, who was required to learn to maintain as small a pattern of bullet dispersion as possible. Adequate reliability was obtained (0.80 to 0.85), and learning continued with no evidence of complete mastery by the end of some 30 trials of 3 bursts of 12 rounds each. Performance of gunners using a new mount and an old mount gave clear evidence of the superiority of the new mount over the old, insofar as pattern size was concerned.

The Poorman Range was a ground installation which did provide a fair simulation of the gunner's sighting problem. The gun position was mounted on a rotating base. The gunner was required to track in a direction opposite to the rotation of the base, using as a reference point a small track-mounted model plane traveling through a path which simulated mathematically the path of an attacking fighter. If the gunner applied Position Firing deflections properly, his guns would remain pointed at the center of a stationary cloth target. Number of hits on this target provided the gunner's score. The estimated reliability of scores obtained for 15 trials of 60 rounds each was 0.56. Learning was typically rapid at first, with some leveling off though no evidence of complete mastery at the end of 13 trials of 60 rounds each. Untrained gunners, though inferior to trained gunners during early trials, quickly caught up with the more experienced men and performed as adequately throughout the latter trials. The Poorman Range was not widely used in the Training Command,

but it was considered very favorably by gunnery officers in the training air forces.

Another ground range involved the firing of machine guns at radio-controlled target airplanes. Though the planes could be brought to earth occasionally by direct hits, with attendant excitement, the total number of hits registered was too small to expect that reliable scores could be obtained. Further, the guns were fired in battery which prevented the gunner from obtaining knowledge of results of his firing. On the whole, the OQ-3 Range, as the radio-controlled target range was called, was considered to have interest value and little else.

Upon completion of ground training, gunners were given a period of training in the air. One form which this training took was to fire from a bomber at a sleeve or flag target towed by another airplane. Except for familiarization with the firing of guns from a bomber, this type of practice, called air-to-air firing, was considered to have little value. Reliability of scores seldom rose significantly above zero, and instructional possibilities were very limited. However, air-to-air firing was continued throughout the war, in the absence of any fully adequate substitute.

The gunner's sighting and tracking problem was closely simulated in gun camera exercises. Using sights equipped with 16 mm. moving picture cameras, the gunner would simulate fire at an attacking fighter. Scoring the film usually involved the measuring of deviations of the reticle of the sight from its proper position in relation to the target, a task which could be done with adequate consistency if proper care were taken. The main source of unreliability in gun camera scores were variations in fighter attacks, bomber courses, air turbulence, harmonization of guns, and similar factors. For attacks within a single mission, average reliabilities were typically of the order of 0.45 to 0.65. Between missions, however, intercorrelations ranged from 0.05 for one type of score to 0.42 for another. The rank order correlation (uncorrected) between scores on the first 5 and on the second 5 of 10 comparable missions ranged from 0.56 to 0.75, for different measures. In general, it may be said that scores of satisfactory reliability could be obtained on gun camera performance providing enough exercises were given with conditions held at uniform as possible. When learning was studied, there was little evidence of improvement on the part of men who had completed their gunnery training; however, untrained gunners showed improvement, particularly those using the Martin turret. Though the evidence of its benefits were not clearly established, the gun camera was considered to be the best single training situation available during the course of the war.

A device which promised to provide excellent air training experience was the Firing Error Indicator. This was a radio system, composed of a transmitting unit in a target glider and a receiving unit in the bomber, which supplied signals indicating the distance and magnitude of misses when caliber 0.50 projectiles were fired at the target. The combat situation was simulated closely and the gunner was provided with immediate knowledge of results in a most useful form. The reliability of scores on this device was not determined. There was evidence of learning in an exploratory experiment, but there was no evidence of transfer to gun camera performance. Although the evaluation of this device was not completed, every indication was that development should be continued.

The Frangible Bullet Trainer in many respects provided an excellent training situation. Gunners fired a special caliber 0.30 projectile at an armored fighter; the projectiles would disintegrate harmlessly on impact. Hits were indicated by a flashing light and recorded by a system of counters in the fighter. There was some evidence of learning, although the reliability of scores was very low. The average percent hits obtained in one study was three, which limited the tuitional value of the device. Changes in ballistic factors occasioned by the use of a lighter and slower projectile also presented difficulties which were not overcome with complete satisfaction by the modification of sights. It is possible that the introduction of radar fire control equipment on bombers would increase the number of hits obtained on the Frangible Bullet Trainer sufficiently to yield more satisfactory scores and possibly increase the validity of the sighting operation.

A study of a system of visual training conceived as a means of improving the perceptual skills of gunners, and several investigations of instruction in aircraft recognition are reported in the body of the report, but are not summarized here for they were not of appreciable importance in gunnery training.

The Attitudes and Adjustment of Gunners

At various times during the war, the attitudes and adjustment of gunners were studied. The value of these studies was largely contemporaneous, aiding in the shaping of current policies. Taken together, the studies now provide something of a stereoscopic view of the men who are the concern of this report. One of the studies of the adjustment of gunners is believed to be of enduring significance.

In general, gunners were satisfied with their assignments. One study revealed that 75 percent felt that being a gunner was better than most Army assignments, and 73 percent felt that they

would make good gunners. Of the same group, 81 percent felt that the gunner's job was as important as that of the bombardier, navigator, or pilot on a bomber. Attending gunnery school usually increased the incidence of favorable attitudes. Most gunners looked forward to combat. At least 50 percent said that they would be disappointed if they did not get into combat; about 25 percent were undecided; and 25 percent evidenced no enthusiasm, on a questionnaire. After combat, only about 15 percent desired to return for a second tour of duty. Most gunners, about 85 percent, felt that their gunnery training was from good to excellent. However, gunners in combat were able to make many specific recommendations for the improvement of the training they had received. Combat experienced gunnrs most frequently felt that their training in operating their equipment in the air had been deficient.

The assignment of gunners who had completed one tour of combat duty presented difficulties. Although the experience and prestige of these men made them potentially useful, their relatively high rank and their adjustment difficulties made special handling of their assignment necessary. The attitudes of training officers towards returnees varied from the opinion that they were trouble-makers to the opinion that they had much to offer in the training program if they were given the opportunity. Early assignment policy was obviously inadequate and many returnees expressed resentment against the jobs given to them. Later, policy improved so that about 70 percent of one large group studied felt that the Army was making good use of their ability and experience; 68 percent expressed satisfaction with their assignment; and 70 percent felt that they were doing a good job. There was little enthusiasm for an assignment to a second tour of combat duty. In one study 15 percent of the men indicated some desire for a second tour, and an additional 16 percent were indifferent. Most men felt that they had had enough of combat. Attitude toward a second tour of duty was affected by the reaction of gunners to the experiences they had had on their first tour. Those gunners who had most frequently or intensely experienced fear in combat and those who had suffered from operational fatigue were less willing to return to the combat situation.

Prior to combat, about half of the gunners in one study indicated some concept of the goals for which they were fighting, though their expression was doubtlessly molded by the questionnaire used. In an intensive study of 100 returned gunners, it appeared that returnees were more inclined to question the basic values of the war than were precombat gunners. An appre-

ciable percentage of returnees, about 40 percent, expressed some dissatisfaction with the civilian population.

Combat left its mark upon most returning gunners. Ninety percent of the men experienced fear in combat equal to or more severe than any other fear they had ever experienced. About 40 percent of one large group of returnees had been diagnosed as having had operational fatigue in at least some degree of severity. In a more intensive study of 100 men, 24 percent had exhibited severe combat fatigue and, an additional 50 percent had shown a moderate degree of combat strain. The problem was obviously serious enough to merit careful study. Such a study was conducted under the supervision of Dr. Carl R. Rogers, primarily to determine what factors were most closely associated with adjustment during and after combat. It was concluded that the following factors were sources of psychological strength in combat: a high degree of security in a social group, a high degree of security in family relationships, security in religious faith, independence, clear purposes and goals, superior ability, and constitutional stability. Early adjustment and the ability to form strong group relationships were considered to be most significant. Other findings are included in summary form in preceding paragraphs of this section. A number of recommendations were made which were of immediate value in shaping policy with reference to the treatment of men returned from combat.

The usefulness of attitude studies was apparent during the war. In view of the fact that the systematic accumulation and processing of data on attitudes is a relatively straightforward undertaking, it would seem profitable in such a large scale training program to have routinely collected materials on the attitudes of gunners on entrance to gunnery school, on completion of training, just prior to combat, and immediately following combat. Studies of special groups, such as instructors and gunnery officers, might also have been fruitful.

The Development and Evaluation of Training Programs

Whereas the research which has been summarized so far contributed indirectly to the improvement of gunnery training, psychologists were also directly responsible for assisting in the development of training programs and for their evaluation in operation. This task was complicated by the diversity of gunnery training and by the frequent changes made necessary by the introduction of new equipment. In such a fluid training situation, it was impossible to achieve uniformity by directives from higher headquarters, for the planning and execution of programs involved the efforts of a large number of people. It is believed that

psychologists contributed effectively to achieving uniformity in training by defining and sponsoring certain principles which were evolved from experience accumulated in the program, and which also reflected well established principles of learning. The need for clear definition of objectives, for basing course content on these objectives, for drawing from established principles in planning teaching procedures, for objectively evaluating the results of training, and for revising training procedures in the light of research findings were stressed. More detailed principles for guiding work on specific problems, such as the development of training aids and of training devices, were gradually worked out and used in program planning. The evaluation of training programs in operation made use of several techniques, the most notable of which were the experimental comparison of a new and an old program, the measuring of the proficiency of gunners arriving in combat theaters, the interviewing of gunners, and the studying of some specific unit of work within the program.

Several studies of the effectiveness of gunnery training were undertaken. One of the first of these had as its objective the measuring of proficiency of gunners in combat air forces, the obtaining of information required for planning tests for the selection of gunners and of gunnery officers, and the investigation of the adequacy of various materials included in gunnery curriculums at the time. Psychologists were sent to the Seventh Air Force, the Fifth and Thirteenth Air Forces, and to the China-Burma-India Theater for these purposes. The proficiency aspect of the study indicated that none of the gunners studied was as proficient as the average basic gunner in weapons and sighting, and that most of these men actually received failing scores on the measures used. On turrets, about one-third of the men studied reached the level of the average gunnery student, and one man proved to be above average. It was apparent that gunners were arriving in combat theaters unprepared to do their jobs.

The project reports resulted in a reexamination of gunnery training in the States. Attention was focussed on the training air forces in particular, and a study, known as the Pueblo Project, was undertaken to demonstrate the effectiveness of an advanced training program which stressed increasing motivation, providing opportunity for guided practice, and teaching the gunner's job as a unified performance. The gunners trained under the new program were markedly superior to those trained under the old program; 97 percent of the experimental group achieved perfect scores on turret phase checks and only 38 percent of the gunners trained by traditional methods achieved perfect scores. The efficiency of training in the new program also made it possible to

use saved time to train gunners on secondary turret positions, and thereby increase their usefulness to a combat air force. The procedures used in the experimental program at Pueblo were adopted and made standard for all training air force stations in the country.

The possibility of increasing the length of the basic training program was also considered. Prior to adopting a new program, it was decided to determine what gains might be expected from increasing the course from 6 weeks to 8 weeks. This decision was significant for it reflected an acceptance of the viewpoint that new procedures should be tested prior to adoption. The 8-week students were found to be superior in knowledge of gunnery, no more proficient in care of equipment, slightly superior in use of equipment, and appreciably better in their attitudes toward gunnery and gunnery training. When the two groups were followed up in advanced training, no differences were apparent. On the basis of this study, it was possible to recommend that the 6-week course was adequate during periods of crisis when time was critical, but that gains were to be found in an 8-week course if the time could be afforded.

The studies of the proficiency of gunners in combat theaters helped establish the idea that gunners should be given training from the day they entered gunnery school until they had completed their last combat missions. An intense period of training followed by many months of sporadic training or no training at all could not be expected to result in highest combat efficiency. In an attempt to identify the most efficient procedures for maintaining the proficiency of gunners during their combat tour, an evaluation of four types of training routines was undertaken in the Eighth Air Force. This study indicated the superiority of gunners trained under two of the proposed programs, and recommendations were made for what appeared to be a fairly satisfactory program for in-combat training of gunners. Finally, gunners who had completed their combat tours and returned to this country for retraining for a second tour of duty were subjects in an experiment designed to determine how much refresher training they would require to bring them up to the level of proficiency of current gunnery graduates. It was found that 3 weeks of refresher training was sufficient to achieve the desired objective.

The Selection and Training of Gunnery Instructors

The importance of the individual gunnery instructor in determining the general level of gunnery training was recognized early in the psychological research program, and persistent efforts were

made to improve the functioning effectiveness of these men. There were three general types of gunnery instructors: the classroom instructor, the ground range instructor, and the air firing instructor. Since type of instructional assignment could not be predicted with certainty, it was considered necessary for all graduates of the Instructors Course to be able to take over any of the various instructor jobs, either in gunnery schools, on a training air force station, or in a combat air force squadron. A wide range of possible job assignments, many of them requiring different abilities as well as different knowledge and skill, made it necessary to select gunnery instructors for general abilities and to follow up selection with general training.

The ideal measure of the competence of the gunnery instructor would have been some measure of the proficiency of the men whom he trained. In the absence of such a measure, it was decided, on the basis of an analysis of the gunnery instructor's task, that intelligence, knowledge of gunnery, personal adjustment, and an understanding of the principles of teaching were of most significance. Intelligence could be measured by available intelligence tests; personal adjustment might be measured by tests validated against instructors of the Instructors School staff whose adjustment was considered to be satisfactory; and knowledge of gunnery could be measured by one of the comprehensive examinations that had been developed for such purpose. The measurement of teaching proficiency, however, required the establishment of a special situation and the development of a rating scale which would permit relatively standardized observation of instructor trainees in action. To meet this need, and to give future instructors an opportunity to learn by doing, practice teaching classes were instituted in the Instructors Course, and the Gunnery Instructors Rating Scale was devised. The agreement among six specially trained raters using this scale in the practice teaching situation was indicated by a correlation of 0.94 (corrected) between odd-even raters, on the final item of the scale which required a judgment of general effectiveness as an instructor. The fact that this correlation was quite high was attributed to the careful indoctrination given to the raters. With a satisfactory measure of teaching proficiency, there was available a criterion for each of the four areas considered important in the selection and training of instructors.

An early study of the intelligence of instructors serving in the gunnery schools suggested that they represented approximately a cross-section of the student population from which they were drawn, the Army General Classification Test scores of the instructor group being only slightly higher than those of the students.

There was no evidence of a rational and consistent policy of instructor selection. As a first step toward improving the quality of men selected to be instructors, the requirement was established that all instructors must have an AGCT score of 120 or above (or 110 or better in certain exceptional cases), must be a high school graduate, must make a score on the gunnery final examination above that achieved by 75 percent of basic graduates, and must have "the general attributes and attitudes desirable in the task as determined by a competent interviewing officer." These interim requirements were replaced later by requirements based on the Instructors Qualifying Examination, which was specially developed for the purpose. This examination was designed to measure general intelligence, knowledge of gunnery, teaching aptitude, and personal adjustment. It was divided in two booklets, one measuring "aptitude" and the other measuring "achievement." Reliability for both sections was quite adequate. Validity coefficients against three criteria ranged from 0.19 to 0.57 for the aptitude booklets, and from 0.08 to 0.62 for the achievement booklet. The examination was used most extensively in the Personnel Distribution Command to select from among returnee gunners those who should be assigned for training as instructors.

The assistance given in the training of instructors does not lend itself to ready documentation since much of the work was of an advisory nature. The final comprehensive examination and various tests were developed for the Instructors Course; studies were made of combat returnees on the basis of which suggestions were made for their training and use as instructors; manuals were prepared, such as the manuals for instructors and students on interphone procedure; assistance was given in the development of training films; and day-by-day counsel was provided on problems that were individually of no great importance but which in the aggregate composed much of the total problem of instructor training.

The Selection and Training of Gunnery Officers

That gunnery was at first considered a subordinate and not too important function in the operation of a combat aircrew is suggested by the fact that the training and supervision of gunners in combat theaters was normally delegated to various officers in the squadron, few of whom had had any gunnery training. An increased awareness of the importance of gunnery was accompanied by a demand for specially trained officers who could be responsible for the maintenance of proficiency of gunners during their combat tour. Since the job was to be newly created, study of the requirements of the situation in which gunnery officers would operate was

necessary. But haste also was necessary. It was decided, therefore, to make an *a priori* analysis of the duties of the gunnery officer, and on the basis of this analysis, to make tentative plans for a selection and training program. This procedure was followed up by an empirical study, performed by a psychologist sent to the Eighth Air Force, the purpose of which was to validate the assumptions made and to obtain supplementary materials necessary to arrive at a complete and integrated program for selecting and training gunnery officers. It was determined that the gunnery officer first of all had to be able to teach and to organize a training program. He also had to be proficient as a gunner and as a technical expert in gunnery equipment. He had to be a leader capable of enlisting the support of the gunners in his squadron and obtaining the cooperation of other officers with whom he worked. Finally, he had to have qualities of personality and ability that would give reasonable assurance of success in a job for which there was no pattern-setting precedent. The Eighth Air Force study also yielded a series of ratings, by men acting as gunnery officers, of qualities which were considered essential in the gunnery officers who were to be selected and trained. On the basis of those studies, the Gunnery Officers Selection Test was developed. This test consisted of two booklets, the first made up of measures of general intellectual abilities and the second of measures of personality variables considered to be important for gunnery officers. The final form of the test had reliability coefficients for the two parts of 0.87 and 0.89, respectively. The validity of the two parts is suggested by obtained biserial coefficients of 0.42 and 0.18, using pass-fail in the Gunnery Officers Course as the criterion. After the initial curriculum for the Gunnery Officers Course had been planned, psychologists had little responsibility in connection with the work of the school, beyond assisting occasionally on various minor technical problems.

Contributions to Gunnery Equipment, Theory, and Technique

Psychologists in gunnery gave assistance in the development of gunnery equipment and in the formulation and evaluation of gunnery theory and techniques. Much of this work consisted of making judgments and suggestions by drawing from established psychological principles to find solutions to specific problems in gunnery. Some of the work was experimental in nature. The work was considered to be important, for psychological considerations were often neglected in the design of gunnery equipment or in deciding how equipment should be used. For example, the control wheels of the B–29 pedestal sight were so designed that conflicting manual movements were required to frame the target

and to track vertically. Compensating sights were adequate in design but limited in use until experimentation indicated that gunners could use compensating sights against a variety of attacks.

An early experiment investigated the efficiency of several types of sight reticles, a basic problem in equipment design since all sights had some type of reticle. The investigation was prompted by the discovery that gunners tended to underestimate range when using iron ring sights. Of 500 judgments of range, 489 were underestimations. The presence of an optical illusion induced by the design of the sight was suspected. The hypothesis was that the circular ring superimposed upon a fighter tended to make the apparent size of the fighter greater than it would be if the ring were not present. Therefore, the ring for one sight was removed, leaving only the cross-hairs, and performance on this modified sight was compared with performance on the standard sight. When the ring was removed, the error in estimating range was significantly reduced. The possibility that a size constancy phenomenon was also operating was suggested by the fact that estimation of range was more accurate when an optical sight was used; the optical sight had a collimating lens system which eliminated most of the conditions favorable to the occurrence of size constancy. The possibility that eye-dominance might be significant in sighting was also explored, though not exhaustively. Tests of a special gun grip which facilitated the use of the dominant eye in aiming were compared with the traditional grip. No significant differences were found. An additional equipment problem arose when it became desirable to install gun cameras for B-29 sights for use in combat. There was some hesitation to install cameras for fear of upsetting the balance of the sight. Comparisons of standard sights with counterbalanced camera-equipped sights indicated that the installation of the camera did not significantly affect the gunner's performance.

Increasing the versatility of existing equipment was often more rewarding than attempts to have equipment modified to incorporate improvements, since equipment changes consumed much time. Several gunnery officers suggested a simple rearrangement of the ring and the post on ring-and-post sights to make it unnecessary for the gunner to keep his head a given distance from the ring. The accuracy of sighting when using the two systems indicated some superiority for the proposed modification. The adoption of the new method was recommended.

The defensive strength of a bomber formation was decreased by the fact that most gunners could fire effectively only at fighters attacking their own bomber. Lending support fire to a neighbor

ing bomber was not feasible, when using noncomputing sights. The use of compensating sights for support fire was known to be possible mathematically; however, there was doubt whether gunners could make the perceptual judgment required to apply the mathematically determined deflections. The judgment involved estimating the "aspect angle" of the fighter, or the degree to which the nose of the fighter was turned away from the gunner's bomber toward some other bomber. On the basis of studies of the ability of gunners to judge aspect angles in a static, laboratory situation, the recommendation was made that the aspect angle method of firing be used. The procedure was incorporated into Air Force doctrine. To verify the soundness of the recommendation, the studies were repeated in the air. It was found that gunners could estimate support fire deflections using the aspect angle system as effectively as they could judge deflections required for defense of their own bombers when using simple ring sights. This development illustrates well the productive role of psychological research in a practical situation. A problem existed for which an immediate solution was demanded. The solution recommended was based upon the best available, though limited, experimental evidence. A tactical doctrine was formulated and put into use. The recommended procedure was then verified, and checked for possible revision, by more extensive experimentation.

CRITICAL EVALUATION

An attempt will be made in the paragraphs that follow to evaluate briefly the work of psychologists in gunnery and to summarize some hypotheses, growing out of the gunnery research program, which may be of value to other research groups.

The Concept of the Job To Be Done

A first question that one would ask of a research program is how adequate was the conception of the goals and the functions of the program. The fact that the objectives of gunnery research were frequently examined by the officers responsible for the program may lend substance to this final evaluation.

The objectives of psychological research in gunnery changed during the course of the war. Thus the most thoughtful conception of the work during one period would not suffice for a subsequent period. With the exception of one period, however, it is believed that the over-all program of pschological research in gunnery was accomplished with objectives and purposes which were clearly formulated and generally understood. Early research in gunnery was directed towards the developing of selection tests. This was an appropriate function for psychologists in the Army,

there being established precedent for this type of work. In seeking criteria for the validation of selection tests, investigations were made of training procedures, which led to a redefining of the objectives of psychological research to include research on training. Although training research is certainly an appropriate field of endeavor for psychologists, the entrance of aviation psychologists into the field of training was accompanied by some confusion in objectives. Neither psychologists nor training personnel had a clear concept of the new job that psychologists were undertaking. As the new work was getting under way, psychologists in gunnery research somewhat inadvertently became involved to some extent in the actual operation of training. Regardless of the justification of this at the time, it seems fairly clear now that the attendant confusion of objectives worked to the disadvantage of gunnery research. The need for this nonresearch activity was diminished by the assignment of additional training personnel to the Central School, and psychologists focussed all of their efforts on improving gunnery through research. There gradually evolved a clear concept of the objectives of psychological research on problems of gunnery training. These objectives may be summarized as follows: to cooperate with other specialists in the development of techniques and procedures for the selection and training of gunners, of gunnery instructors, and of gunnery officers; and to devise more efficient means of using gunnery equipment, through the application of experimental techniques or of principles drawn from the general body of psychological knowledge. Finally, a temporal qualification was added to these objectives: work which would most immediately produce better gunnery would be given highest priority.[2]

Levels of Research

In planning psychological research in gunnery, the concept of levels of research was useful. The essential feature of this concept is that research should be carried on at several levels simultaneously, particularly in an activity that is likely to continue over a period of years. Some projects should be directed toward the immediate solution of problems that are generally considered im-

[2] The wisdom of this latter decision may be open to question. However, that it was implicit in all of the planning of gunnery research should be kept in mind to understand why some projects received much attention, others little. Thus much work was done on phase checks, very little on perceptual problems in the design of sight reticles. Phase checks might mean better gunnery immediately; new designs of sight reticles might mean better gunnery but only at a distant date. Further, the efforts of psychologists were diverted occasionally from psychological research, as, for instance, to test and sponsor a simple device which would eliminate the chief source of gun-stoppages and which could be used in combat immediately. To have neglected such projects, when there was no one to whom they could have been given, would have been to lose sight of the ultimate objective of the war.

portant by the personnel responsible for the over-all activity. There is an element of opportunism in this, but no apologies need be made. Such short term projects often make substantial contributions to the activity, and they are often the source of confidence which will sustain research on more fundamental problems. A second level of research should encompass problems that study has revealed to be critical to the ultimate success or failure of the activity. In gunnery research, problems of instructor selection, of curriculum planning, of criteria of proficiency, of adequacy of training devices, were of this nature. Most effort was devoted to them, and they were thought of as continuing projects. A third level of research should concern itself with problems, the solutions to which are likely to introduce fundamental changes in the activity concerned or to provide basic information required for use in solving other problems. Studies of the design and manner of operation of equipment are examples of this level of research, in gunnery.

Planning and Execution of Specific Research Projects

Planning for specific projects varied in quality, though it is believed that plans were formulated, in general, with adequate foresight and thoughtfulness. The development of achievement tests, of phase checks, of the Gunnery Officers Selection Test; the evaluation of several training devices; the study of the adjustment of excombat gunners; the advisory work in relation with the production of the Gunner's Information File and of training films; the assistance given in the planning of the B–29 gunnery training program; the experimental work on the use of compensating sights for support fire; the program developed for the selection of gunnery instructors, and perhaps others, are believed to have been planned and executed with satisfactory competence. Other important projects, notably the Pueblo Project, the Eighth Air Force Project, the studies of the proficiency of gunners in three theaters of operation, while falling short of accepted canons for experimental work were, nonetheless, of undeniable importance in improving gunnery training. Their planning and execution suffered from the limitations likely to arise in a large research project carried on in an operating program. The evaluations of the Firing Error Indicator and of the Frangible Bullet Trainer were limited in scope, although these were two very important training devices. The studies of the AFSAT B–29 Trainer, due primarily to confusion in authority, were poorly designed. A number of minor studies were started and not pushed through to satisfactory completion. This was particularly true of the development of personality tests. Perhaps the most culp-

able neglect was of projects pertaining to the motivation of gunners. Efforts were made to initiate work in this important area, but little was accomplished. On the credit side of the ledger would be several projects conducted in cooperation with other research groups, in which gunnery psychologists gave assistance in the planning and sometimes in the execution of the work done. Notable among these projects was a large-scale evaluation of various types of sights.

The Reporting of Research Results

The design and execution of research projects were generally superior to the reporting of the results of the work done. There were two identifiable reasons for this. The first was that reports were written for two audiences, gunnery training personnel and other psychologists. The result was that neither group was completely satisfied. The second was that the writing of reports often assumed importance secondary to the immediate application of results of research to the solution of a problem. Thus it would have been possible to make a decision basic to the formulation of doctrine for support fire without writing up the results of related aspect angle studies. Of course, neither of these two problems is without an apparent solution. In such circumstances, it would probably be best to have all research projects written up in complete detail for a scientific audience and then have a professional writer rework the material for general use. The second problem can be solved by administrative insistence that a project is not completed until it has been reported. Some of the sections of this final report reflect the inadequacies of the original reporting of projects.

By-products of Research in Applied Psychlogy

A problem related to the planning, execution, and reporting of some research in applied psychology has to do with an outcome of research which is corollary to the experimental results *per se.* When an operating training program is studied experimentally, the most significant outcome may be the interest which the students and supervisory personnel take in the study. Experimental work is no longer necessary to prove that increasing motivation and increasing practice will probably result in increased learning, if other conditions are favorable. But such experimental work often proved, in gunnery research, to carry conviction which no amount of persuasion could accomplish, and to result in a general tightening of instruction which would spread to many related activities. Thus the Pueblo Project, which added nothing to knowledge of psychology, convinced responsible officers that the general level of training accomplished in the training air forces

could be raised appreciably. The gunnery program for all training air forces stations was consequently revised to incorporate principles of training which had long been established but which needed the conviction-carrying results of an experiment done in gunnery itself.

Meeting the Needs of the Using Agency

A prime consideration in the evaluation of an applied psychology program is the extent to which the work done meets the needs of the agency concerned. There are many indications that psychological research in gunnery fulfilled a real need. The rapid growth of the research organization attests this in part. More convincing is the fact that there was hardly an area in the training of gunners which was not influenced at least to some extent by the outcome of research and developmental work to which psychologists contributed, as is reflected in the contents of the preceding chapters. A corollary problem is the extent to which the research work is geared temporally to the demands of the operating agency. Here the picture is not so clear. Much of the work done in research was paced just ahead of the fully recognized needs of training, and a selling of research results was necessary. For instance, the instructor selection program met with opposition, at first, though the high quality of gunnery instructors selected by the program later became a source of pride to gunnery personnel. On the other hand, demands were often made by training personnel which could not be met. The tentative form of one of the first phase checks precipitated a demand that phase checks for all types of activities be prepared by a certain date. The date set appeared reasonable but did not consider the time-consuming process of preparing and testing many phase check items, and it was not possible to meet this request in the time allowed. On the whole, however, it is believed that psychological research in gunnery measured up fairly well on this criterion of the adequacy of a research program.

Contributions of Enduring Significance

Finally, the question should be asked if any of the work done could be considered to have more than ephemeral significance. By this most rigorous of criteria, the gunnery research program falls short, insofar as specific contributions are concerned. The full development, in phase checks, of a valuable performance testing technique might be considered important. The studies done on training devices are possibly distinctive by virtue of their comprehensiveness, but the devices themselves have such limited use that this work may best be considered for its wartime applications. Some of the studies on use of sights may provide suggestions for

further research on fundamental problems of visual perception. The training programs developed and evaluated may have long range value as illustrations of the effective application of principles which have long been recognized as sound. Nothing new was added to knowledge of selection procedures, an adequate job simply having been done to meet an immediate need. Thus it seems accurate to say that few of the specific findings of gunnery research are of enduring importance.

However, in the research program as a whole there can be found a pattern for the cooperative work of scientists in varied fields, a pattern which should certainly be given careful consideration for its significance, which may possibly be fundamental. In gunnery research, men of varied training and interests combined their efforts in seeking solutions to a complex problem, a problem which had at its core the functioning ability of large numbers of people. The tradition of isolation of scientific groups, which is frequently reflected in the organization of university staffs, civilian research groups, and Army research programs, gave way to a program calling for joint endeavor in which activities were determined primarily by the nature of the problem rather than by the special research interests of the men involved. It is believed that some of the more urgent of current problems, which essentially involve the behavior of large numbers of people, may best lend themselves to solution by the cooperative work of many kinds of specialists.

APPENDIX A

Research Division Personnel Engaged in Psychological Research[1]

Adams, Jack D., Master Sgt.; Sgt. Maj., Admin.

Angoff, William H., Lt.; Stat.

Bainbridge, Robert G., Staff Sgt.; Psychol. Tests.

Benham, Marion C., Capt.; *Director, Curriculum Development.*

Beyers, Otto J., Capt.; *Director, Technical Statistics.*

Boxer, Nathan, Sgt.; Psychol. Tests.

Bragarnick, Robert, Maj.; *Director, Proof Section,* Overseas Proj.

Carey, Lee A., Staff Sgt.; Psychol. Tests.

Charles, Raymond A., Cpl.; Stat.

Cohen, Walter, Cpl., Proof, Valid.

Collins, Robert A., Capt.; Curric. Eval.

Ellingson, Robert J., Staff Sgt.; Psychol. Tests, Publ.

Estes, William K., Lt.; Psychol. Tests, Valid.

Feiner, Arthur, Pfc.; Psychol. Tests.

Flowers, Richard, Lt.; Curric. Eval.

Forstenzer, Hyman. Sgt.; Psychol. Tests.

Freeman, Paul, Sgt.; Psychol. Tests.

Gallagher, Thomas P., Lt.; Valid., Curric. Eval., Psychol. Tests.

Garber, Lee O., Capt.; *Director Curriculum Evaluation.*

Gibian, Everett, Cpl.; Curric. Eval.

Gleason, John F., Technical Sgt.; Admin.

Goldstrom. Herbert W., Sgt.; Psychol, Tests.

Goodman, Rudolph, Sgt.; Valid., Curric. Eval.

Gordon, David, Cpl.; Psychol. Tests.

Gordon, Phillip L., Staff Sgt.; Stat.

Gregory, Wilbur S., Capt.; Valid., Overseas Proj.

Greenwood, Morgan A., Capt.; Proof.

Haire, Mason J., Capt.; *Director, Validation,* Psychol. Tests, Overseas Proj.

Harris, Frank J., Lt.; Curric. Eval., Overseas Proj.

Henderson, Kenneth B., Capt.; Psychol. Tests.

Histon, Daniel J., Lt.; Proof.

Hobbs, Nicholas, Maj.; *Director, Research Division.*

Huber, Jack T., Sgt.; Psychol. Tests, Publ.

Humphrey, Ingram, Lt.; Curric. Eval.

Irion, Arthur L., Lt.; NCOIC, Special projects; Proof, Valid.

Jensen, Alfred C., Capt.; Psychol. Tests, Valid., Overseas Proj.

Kaitz, Hyman B., Technical Sgt.; NCOIC, Technical Statistics.

Ketchersid, Ernest E., Sgt.; Stat.

Lawrence, James F., Lt.; Curric. Eval., Valid.

Leedy, John L., Sgt.; Psychol. Tests.

Levine, Alexander N., Sgt.; Curric. Evaluation., Valid.

Liebenberg, Maurice, Cpl.; Publ.

Lieberman, Milton G., Sgt.; Stat.

Lubin, Ardie, Sgt.; Stat.

Matheny, William G., Technical Sgt.; Valid.

McQuitty, John V., Maj.; *Assistant Director, Research Division.*

Neely, James H., Cpl.; Curric. Devel.

O'Hara, John G., Lt.; Psychol. Tests.

Pascal, Gerald R., Lt.; Psychol. Tests, Valid.

Payne, Riner C., Staff Sgt.; NCOIC, Valid.

Ray, Esten W., Lt.; Valid.

Reinders, Victor A., Lt.; Valid.

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[1] For duty assignments, the following abbreviations are used: Admin., Administration; Curric. Devel., Curriculum Development; Curric. Eval., Curriculum Evaluation; Overseas Proj., Overseas Projects; Phychol. Tests, Psychological Tests; Publ., Publications; Stat., Technical Statistics; Valid., Validation; NCOIC is non-commissio d officer in charge.

Rosevear, William H., Lt.; Valid.

Russell, Roger W., Maj.; *Director, Validation and Curriculum Evaluation*; Overseas Proj.

Schrader, William B., Lt.; Valid., Curric. Eval., Psychol. Tests.

Stolurow, Lawrence M., Capt.; *Director, Psychological Tests.*

Trent, John, Lt.; Curric. Eval., Psychol. Tests.

Valentine, John A., Capt.; Psychol. Tests, Publ., Overseas Proj.

Vallance, Theodore R., Capt.; *Administrative Executive.*

Wagner, Ralph F., Lt.; Valid., Radar Team.

Waldman, Marvin, Staff Sgt.; NCOIC, Psychological Tests.

Wepman, Joseph, Lt.; Psychol. Tests, Curric. Devel.

Werwath, Herbert D., Lt.; Proof.

Wilson, Dale K., Staff Sgt.; Valid.

Willey, Clarence F., Lt.; Valid., Consultant, Poorman Range.

Wischner, George J., Lt.; Valid., Proof; NCOIC, Personnel.

Wolin, Burton R., Staff Sgt.; Curric. Eval.

APPENDIX B

Statistical Data

APPENDIX B

TABLE 1.—*Intercorrelations among 12 proposed gunnery selection tests and composite score on 10 Aviation Cadet Classification Tests (N=953 gunnery students; Tyndall, Class 42-42, 1943; Harlingen, 42-41, 1942; Las Vegas, 42-40, 1941; October 1942)* [1]

Test	Code	1	2	3	4	5	6	7	8	9	10	11	12	13
1. AGCT			0.47	0.22	0.52	0.25	0.49	0.39	0.49	0.23	0.34	0.14	.013	0.54
2. MA		0.47		.43	.27	.40	.37	.35	.42	.40	.38	.33	.17	.61
3. Mechanical principle	CI903A	.22	.43		.05	.16	.35	.14	.30	.15	.25	.38	.18	.51
4. Numerical operation	CI702B	.52	.27	.05		.24	.45	.50	.31	.29	.29	.11	.17	.52
5. Speed identification	CP610A	.25	.40	.16	.24		.13	.15	.20	.53	.29	.21	.19	.53
6. Mathematics	CI708A	.49	.37	.35	.45	.13		.43	.46	.17	.28	.14	.07	.55
7. Numerical approximation	CI602E	.39	.35	.14	.50	.15	.43		.31	.22	.27	.08	.12	.47
8. Technical vocabulary	CE505C	.49	.42	.30	.31	.22	.46	.31		.23	.26	.13	.12	.58
9. Spatial orientation	CP501B CP503B	.28	.40	.15	.29	.53	.17	.22	.23		.34	.21	.18	.60
10. Speed reaction	CP611D	.34	.38	.25	.29	.29	.28	.27	.28	.34		.28	.21	.71
11. 2-hand coordination	CM101A	.14	.33	.38	.11	.21	.14	.08	.13	.21	.28		.31	.53
12. Visual coincidence	CP613A	.13	.17	.18	.17	.19	.07	.12	.12	.18	.21	.31		.50
13. Composite (tests 3 through 13)		.54	.61	.51	.52	.53	.55	.47	.58	.60	.71	.53	.50	

[1] For N=1000, a correlation as large as 0.06 would be expected to arise by chance 5 times in 100; a correlation as large as 0.08 would be expected to arise by chance 1 time in 100.

TABLE 2.—*Validity coefficients against 3 criteria for 38 tests administered to gunnery students (various gunnery schools, September-December 1945)*[1]

Test	Code	N	Academic average	Ground-to-ground firing	Air-to-air firing
Qualifying examination	AC10A				
Part I		284	0.47**	0.14*	0.06
Part II		284	.52**	.11	.00
Part III		282	.40**	.25**	.14*
Part IV		284	.60**	.16**	.01
Part V		284	.42**	.19**	.01
Part VI		284	.51**	.15*	.00
Memory for plane silhouettes	CI503A	248	.20**	.14*	.27**
Plane name memory	CI506A	248	.23**	.25**	.19**
Memory for names	LV3C	250	.44**	.10	.15
Judgment in aiming	LV6A	124	.16	.05	.03
Reading comprehension	CI618A	248	.23**	.00	.12
Reading comprehension	LV4B	228	.37**	—.01	.01
Speed of identification	CP610A	148	.27**	.14	.10
Speed of identification	FTC	318	.21**	.08	.08
Speed of perception	LV5B	115	.24**	.08	.02
	LV7A	123	.19*	.10	
Estimation of angle of approach	LV8A	121	.06	.14	
Quantitative perception III (total 3 scores)		248	.17*	.16*	.08
Quantitative perception III (total 4 scores)		248	.21**	.20**	.19**
Shorter line	CP606A	248	.01	.07	
Shortest path	CP603A	250	.22**	.11	.03
Nearest point	CP607A	250	.15*	.02	.07
Map distance	CP626A	250	—.02	—.06	.03
Map-path distance	CP628A	248	.10	.12	.06
Pattern comprehension	CP803A	315	.23**	—.11	.14*
Pattern assembly	CP804A	315	.17**	.09	.14*
Judgment of proportions	CP206A	250	.26**	.03	.03
Judgment in aiming	LV6B	120	.14		
		124	.16	—.05	.03
Spatial orientation	CP501A	272	.20**	.14*	.18**
Directional orientation	FTG	313	.41**	.09	.04
Instrument comprehension	CI616A	250	.17**	.01	.02
Inventory:					
Inferiority		245	—.17**	—.09	—.12
Ascendance-submission		245	.06	.01	.14*
General motility		245	.04	—.04	.08
Masculinity-feminity		245	.13*	—.05	.05
Nervousness		245	—.06	—.05	—.03
Numerical approximation	CI706A		.27	—.02	.04
Numerical operations	CI702B	225	.27**	.09	.03
Mathematics	CI702F		.24	.04	.05
Mathematical proportions	LV1B	230	.42**	.14*	.06
Technical vocabulary	CE505Cr	270	.20**	.01	.14*
Following directions	[illegible]402A	250	.38**	.08	—.05
Mechanical principles	CI903A	275	.06	.14*	.24**
Mechanical information	CI905A		.07		
Tool function	CI906A	120	.12		
Mechanical function	CI907A	121	.17	.06	
Mechanical movements	CI904A	248	.33**	.16*	.15*
		121	.11	.23**	

[1] For the validity coefficients, the number of times in 100 that a coefficient as large as each one obtained would be expected to arise by chance is indicated by the following system:
No asterisk: more than 5 times in 100.
*Between 1 and 5 times in 100.
**Less than 1 time in 100.

TABLE 3.—*Reliability and validity coefficients of experimental tests from which parts of aptitude test for aerial gunners, AC30A, were drawn (various gunnery schools, September-December 1942)*

Exploratory tests		Validity				AC30A
Name	Reliability[1]	N[2]	Academic grades	Ground range scores	Air-to-air	Designation of part
Mathematical proportions	0.87	230	0.12	0.14	0.06	VA
Memory for names	.92	230	.16	.10	.15	II B
Plane-name memory, C[illegible]306A	.82	248	.23	.25	.19	II
Gunnery mathematics	.94	------	.31	.12	.04	V B
Gunnery interest	.86	------	.40	.07	.22	I
Gunnery learning	.80	------	.41	.08	------	III A, C
Gunnery technical vocabulary	------	------	.40	------	.14	I
Mechanical principles, CI903A	------	275	.08	.14	.24	IV
Speed of identification, CP610A	------	148	.27	.14	.10	VI

[1] The population and method of computation of the reliability coefficients reported are unknown.

[2] Where *N* is omitted, the values reported for the validity coefficients are based on from 1 to 18 classes. Where more than one value was available, the median was used.

TABLE 4.—*Summary of available intercorrelations among Army General Classification Test scores and scores of nine tests used in Developing Aptitude test for Aerial Gunners, AC30A (various classes, Tyndall and Las Vegas; September-December 1942, N is unknown)*

Name and origin of tests	Intercorrelations: Test number 1	2	3	4	5	6	7	8	9	10
Developed at Las Vegas										
1. Mathematical proportions	------	0.33	0.15	------	------	------	------	------	0.17	0.47
2. Memory for names	0.33	------	.36	------	------	------	------	------	.42	.41
3. Plane name memory	.15	.36	------	------	------	------	------	------	.37	.15
Developed at Tyndall										
4. Gunnery mathematics	------	------	------	------	0.29	0.50	------	0.22	------	.41
5. Gunnery interest	------	------	------	0.29	------	.41	------	.50	------	.48
6. Gunnery learning	------	------	------	.50	.41	------	------	.35	------	.50
7. Gunnery technical vocabulary	------	------	------		------	------	------		------	------
Cadet Classification Tests										
8. Mechanical principles, CI903A	------	------		.22	.35	.35	------	------	.14	.22
9. Speed of identification, CP610A	.17	.42	.37	------	------	------	------	.14	------	.25
Army Classification Test										
10. AGCT	.47	.41	.15	.41	.50	.50		.22	.25	------

TABLE 5.—*Intercorrelations among tests in Experimental Test Battery (Class 44-4; Buckingham, N=BGG, January 1944)*

Test	Correlations											M	SD
	1	2	3	4	5	6	7	8	9	10	11		
1. AGCT		0.57	0.42	0.49	0.29	0.29	0.00	0.16	0.08	0.22	0.03	110.28	14.29
2. MA	0.57		.66	.59	.31	.44	—.05	.16	.13	.23	.09	106.42	14.34
3. AC12J	.42	.66		.60	.32	.45	—.08	.30	.20	.15	.08	153.33	27.16
4. AC30A	.49	.59	.60		.35	.32	.03	.24	.10	.19	.11	126.47	25.59
5. Plane formation, CP805B	.29	.31	.32	.35		.25	.14	.14	.10	.02	.09	169.07	24.15
6. Angular judgment	.29	.44	.45	.32	.25		—.01	.19	.18	—.01	—.02	27.61	3.22
7. Estimation of velocity, CP205-N	.00	—.05	—.08	.03	.14	.01		.08	.06	.03	.16	22.74	5.18
8. Identification of velocity, CP205-II	.16	.16	.30	.24	.14	.19	.06		.13	—.08	.09	30.13	5.65
9. Estimation of relative velocity, CP205-III		.13	.20	.10	.10	.18	.03	.13		—.08	.05	29.19	5.72
10. Biographical data blank (gunnery)	.22	.23	.15	.19	.02	—.01	.02	—.08	—.08		—.07	7.87	3.18
11. Opinion poll	.03	.09	.08	.11	.09	.02	.16	.09	.05	.07		283.73	90.96

[1] Positive correlations indicate that "goodness" of performance on the test is essential with "goodness" of performance on the criterion.
For N=300, a coefficient as large as 0.11 would be expected to arise by chance 5 times in 100; and a coefficient as large as 0.15 would be expected to arise by chance 1 time in 100.

TABLE 6.—*Validity coefficients for strength of interest, various stanines, Cadet Classification tests, and age, against each of four gunnery criteria (N=194, class 43-45, Buckingham, November, 1945)* [1]

Test	Code	Mean	SD	Final examination	Jam-Handy	Percent ground range	Percent hits air-to-air firing
Str. of Int.-B		6.6	1.8	−0.01	−0.02	0.11	−0.01
Str. of Int.-N		5.1	1.7	.04	.06	.02	.00
Str. of Int.-P		8.6	1.2	−.06	.00	−.12	.01
Age		22.1	2.5	.08	−.11	.17*	.07
B. stanine		6.1	1.7	.21**	.09	.08	.00
N. stanine		7.0	1.1	.25**	.07	.10	.07
P. stanine		5.4	1.8	.35**	.10	.12	−.03
Aug. P. stanine		5.5	1.8	.34**	.08	.12	−.02
Comp. coord.	CM701A	50.5	9.9	.08	.05	.11	.05
Disc. react. time	CP611D	26.0	4.8	.11	.12	.07	−.08
2-hand coord.	CM101A	47.3	10.2	.10	−.01	.08	−.01
Rot. pur.	CM303A2	24.0	4.8	.03	.03	.04	−.01
Aim. str.	CE211A	50.2	10.8	−.03	.01	.00	.06
Fing. dext.	CM116A	50.6	9.2	−.07	.01	−.03	.00
Tech. vocab.-P	CE505C	10.2	7.3	.45**	.07	.05	−.06
Tech. vocab.-B	CE505C	6.9	2.8	.19**	.10	.01	.03
Tech. vocab.-N	CE505C	13.0	6.8	.26	.02	.12	−.04
Sp. ident.	CP610A	16.5	3.7	.26	.06	.05	−.01
Mech. prin.	CI903A	58.0	16.9	.35	.14*	.11	−.02
Math. A	CI702E	37.5	13.3	.06	−.02	.02	.11
Math B CI206B	CI708A	46.7	12.2	.17*	.11	−.01	.00
Spatial orien. I	CP501B	58.3	11.1	.12	.10	.02	.08
Read. comp.	CP503B	21.3	7.2	.32**	.12	.07	−.01
Spatial orien. II	CI614G	24.3	11.6	.38**	.15*	.10	.00
Mech. info.	CI905A	11.7	8.0	.31	−.08	.08	−.10
Num. Oper.-F	CI702B	21.9	6.4	−.20**	−.01	−.01	−.04
Num. Oper.-B	CI702B	19.5	6.0	−.11	−.01	.04	−.05
D.T. Read.	CP622-21A	35.9	7.6	.03	−.02	.07	07
Mean				131.1	5.0	21.8	130
SD				57	1.9	5.2	5.1

[1] Positive coefficients indicate that "goodness" of performance on one test is associated with "goodness" of performance on the other.

The number of times in 100 that a coefficient as large as each one would be expected to arise by chance is indicated by the following system:

No asterisk, more than 5 times in 100.

*Between 1 and 5 times in 100.

**Less than 1 time in 100.

TABLE 7.—*Validity coefficients for strength of interest, various stanines, Cadet Selection Tests, and age against each of four gunnery criteria (N=178, Class 43—48. Buckingham. December 1943)*[1]

Test	Code No.	Mean	SD	Final examination	Jam-Handy	Percent hits ground range	Percent hits air-to-air firing
Str. of Int.-B		5.2	2.0	—0.20**	0.13	—0.02	0.07
Str. of Int.-N		7.1	1.8	—.08	—.10	.05	—.02
Str. of Int.-P		8.4	1.1	.07	.10	.10	.03
Age		21.7	2.4	.12	.07	.05	.17*
B. stanine		5.9	1.8	.47	—.06	.07	.15**
N. stanine		7.1	1.4	.25**	—.15	.00	.14
P. stanine		4.9	2.0	.53**	—.14	.10	.20**
Aug. P. stanine		5.0	2.1	.52**	—.12	.13	.18*
Comp. coord.	CM701A	46.5	10.8	.40**	—.15	.04	.05
Disc. react. time	CP611D	26.8	4.4	.27**	.01	—.03	.03
2-hand coord.	CM101A	45.7	10.7	.37**	—.05	.07	.09
Rot. pur.	CM803A2	23.7	5.2	.11	.04	.07	.12
Aim. str.	CP211A	46.6	11.4	—.18*	.04	—.08	—.18*
Fing. dext.	CP116A	51.1	10.5	.03	—.06	.07	—.08
Tech. voc.-B	CE505C	19.3	7.1	.31**	—.07	.16*	.25**
Tech. voc.-B	CE505C	6.0	3.2	.22**	.07	.08	.16*
Tech. voc.-N	CE505C	19.7	7.4	.14	—.03	.08	.15*
Sp. ident.	CP610A	16.2	3.9	.24**	.02	—.02	.03
Mech. prin.	CI903A	54.5	20.1	.46**	—.17	.06	.11
Math. A	CI702E	39.6	14.0	.14	—.16	—.02	.02
Math. B	CI708A	47.5	14.0	.15*	—.12	.01	.05
Spatial orient. I	CP501B	58.4	10.7	.30**	.08	.01	.18*
Spatial orient. II	CP503B	20.4	6.3	.16*	—.02	.09	.14
Read. comp.	CI614G	25.4	12.2	.41**	—.23	—.01	.15*
Mech. info.	CI905A	10.3	8.1	.36**	—.15	.06	.15*
Num. oper.-F	CI720B	22.6	6.6	—.09	.01	—.02	.05
Num. oper.-B	CI702B	20.1	6.5	—.08	.02	—.15*	—.03
D. T. Read	CP622-21A	35.6	8.8	.17*	—.01	.01	.13
Mean				28.2	5.1	20.9	13.2
SD				7.1	2.0	6.7	105

[1] Positive coefficients indicate that "goodness" of performance on one test is associated with "goodness" of performance on the other.

The number of times in 100 that a coefficient as large as each one would be expected to arise by chance is indicated by the following system:

No asterisk, more than 5 times in 100.
*Between 1 and 5 times in 100.
**Less than 1 time in 100.

APPENDIX C

Standardized Phase Checks: Stripping and Assembly of the Caliber .50 Machine Gun (Nov. 1944 Edition)

DIRECTIONS FOR ADMINISTERING AND SCORING

1. To the Phase Checker

In order to be certain that graduates from each of the gunnery training units all over the world are equally proficient, it is necessary that each gunner's proficiency be measured by the same phase check given under the same conditions. Also, to be sure that the gunner is retaining what he has learned throughout the various phases of his training and duty, it is necessary to check him at each phase of training and duty on the same phase check, in the same way, and under the most similar conditions possible. That's what is meant by STANDARDIZATION of phase checks. If a phase check is to be fair and accurate, it has to be given carefully and in a uniform manner. Every time you give a phase check, you should give it exactly as it is given by other phase checkers throughout the Air Forces. The directions in this book are complete—know them thoroughly and stick to them, word for word.

2. Phase Check Equipment and Conditions

A. To give this phase check as it is written the following equipment is needed:

(1) This phase check booklet.
(2) Enough copies of the Phase Check Score Sheet.
(3) One complete caliber .50 machine gun.
(4) One work-box for the gunner, in which he will place the disassembled parts until he starts assembling the gun (optional).
(5) One blindfold.
(6) One pair of winter flying gloves or their equivalent.
(7) Combination tool, screw driver, nail, or cartridge (any one or combination of these). Adjustment of buffer adjusting screw requires caliber .50 combination wrench. Worn or unserviceable firing pin may be used for replacement of sear spring.
(8) One headspace and timing gage assembly (A351217).
(9) At least two pencils to avoid leaving the table if one breaks while giving a phase check.

(10) A reliable watch or large clock in view.
(11) A set of broken parts. Do not use the same defective part for two successive gunners or for two working close to each other.

B. Besides complying with the directions concerning checking conditions given in the main body of the phase check, be sure to observe the following conditions also:

(1) Do not administer the phase check to more than one gunner at any one time.
(2) Take a position near the gunner so you can observe everything he does.
(3) Never leave the immediate vicinity of the worktable between the start and finish of the work of any gunner. It is necessary for you to observe closely each man while he disassembles and assembles the gun.
(4) If more than one gunner works at a table, see that each has enough space so that neither will be in the other's way or will get his gun parts mixed from his neighbor's gun.
(5) Bolt or fasten securely each gun to the worktable.
(6) Keep the test room as quiet as possible.
(7) Check each item as the gunner performs it. Unless you continue using the booklet as you phase check, you will begin gradually to give your own phase check instead of a standardized one.

3. Administering the Phase Check

A. On pages 1 through 9 of this booklet, detailed directions for administering the phase check are presented.[1] Follow them word for word.

B. Say nothing to the gunner that does not appear within quotations marks (") on pages 1 through 9. For your convenience, these statements are in prominent type so they can readily catch your attention.

C. Record all data regarding the gunner's performance on the Score Sheet, and be certain that the gunner fills out completely all information about his background on the front and back of the Score Sheet. As soon as this has been filled in on the Score Sheet, insert the Score Sheet into this booklet after page 5 and turn to page 1. A portion of the Score Sheet with numbers and blanks corresponding to the numbers of the phase check items on page 1 will be visible at the right. Starting with page 6 turn the Score Sheet over. The portion of the Score Sheet with numbers and blanks will now be visible at the left. As the gunner performs each item, mark him on that item as follows, on the Score Sheet on the line opposite the number of each item:

(1) Mark zero (0) if he does not perform the operation satisfactorily.
(2) Mark a check mark (V) if he does it satisfactorily.
(3) If for any reason an operation must legitimately be omitted by the gunner, do not record anything opposite the number of that item, but draw a line through the number of the item itself (2).

D. The time a gunner takes to complete a job is important.

[1] Page numbers refer to those printed in large type on original booklet. Pages 1 through 9 correspond to 477–486.

To get this measure of his skill, mark in the appropriate place on the Score Sheet:

(1) Time started field strip.
(2) Time finished field strip.
(3) Total field strip time.
(4) Time started detail strip.
(5) Time finished detail strip.
(6) Total detail strip time.
(7) Total time, field strip plus detail strip.

E. If a gunner makes an error, briefly describe the error under the "Description of Errors" section of the Score Sheet. (Example: "Item 92, placed belt switch in wrong direction for left-hand feed.") Use back of sheet for additional entries if necessary. Identify each entry by the number of the item to which it refers.

F. If a gunner performs an operation satisfactorily, but seems to be slow or weak on that particular operation, describe that weakness under the heading "Describe all Weaknesses" on the Score Sheet. (Example: "Item 92, placed bolt switch in correct position for left-hand feed, but seemed to debate about it for some time—not sure of it.") Items reported in this section will not affect his grade on the test.

G. Never assist or coach the gunner except to pick up any part that falls to the floor and place it on the table or in the work-box.

H. A headspace gage will be used to check headspace adjustments. A combination tool, combination wrench, screw driver, nail or cartridge may be used for all other operations. A worn or unserviceable firing pin may be used to replace the sear spring. Otherwise, parts of the gun will not be used as tools.

I. If a gunner makes any errors, explain his mistakes to him as soon as possible after the phase check is completed, except as indicated in Items 18 and 99. If a gunner fails the phase check, he should have an opportunity to study and practice before taking a recheck.

J. Even though it becomes obvious that the gunner will fail to pass while he is still working on the gun, allow him to complete the entire phase check procedure. Do not tell him that he has failed until he has completed the check. For example, if a gunner does the field strip in 12 minutes, he has failed the phase check, but should go ahead with the detail strip.

4. Scoring

Grade on a five-point scale—five (5) being the best score and one (1) being a failing grade.

A. If a gunner does not perform the field strip within eight (8) minutes, or the detail strip within thirty (30) minutes, give him an automatic grade of one (1).

B. If a gunner makes no errors and completes both the field strip and the detail strip within the allotted time, mark him by means of the conversion table on page V [2]. For example, if a gunner completed the entire phase check in 26 minutes (6 minutes for the field strip and 20 for the detail strip) and made four errors, give him a score of 2. Or if he required a total of 23 minutes (19 for the detail strip plus 4 for field strip) with no errors, give him a score of 5.

C. Place the gunner's final score in the space provided for it.

5. Caution

Remember, if your phase check is to be fair and accurate, you must follow all directions exactly.

SCORING TABLE

TOTAL TIME:
In Minutes, Field Strip Plus Detail Strip.

ERRORS	Under 25	25-29	30-34	35-39	40 or over
0	5	4	3	2	1
1	4	3	3	2	1
2	3	3	3	2	1
3	3	3	2	2	1
4	2	2	2	2	1
5	2	2	2	1	1
6	2	1	1	1	1
7	1	1	1	1	1

6. Field Strip and Assembly

A. Fill in, or have the gunner fill in, his name, field, weapons instructor, the date, etc., in the appropriate spaces on the Score Sheet.

[2] Page V corresponds to this page.

Blindfold the gunner and check to see that the blindfold is secure and the gunner can see nothing. Then help him put on his winter flying gloves.

Observe the gunner to see if he is unusually nervous or ill-at-ease. Do anything possible to put him at east before starting him on the phase check.

Tell the gunner: "FIELD STRIP YOUR GUN. NO ADJUSTMENTS WILL BE NECESSARY." As he starts, put down the exact time he begins in the space provided for that purpose on the Score Sheet. Watch to see that he:

(1) Raises cover and checks feedway.
(2) Charges gun twice properly, making sure cover is closed. (Mark an error if cover is left up.)
(3) Makes sure parts are in battery position before removing backplate.
(4) Removes the backplate. (Mark an error if he fails to remove the driving spring rod assembly completely from the bolt group before removing the bolt group.)
(5) Removes the bolt stud, and removes the bolt group.
(6) Rotates cocking lever to the rear. (Mark an error if he depresses sear before doing this.)
(7) Releases the firing pin by depressing the sear.
(8) Depresses oil buffer body spring lock. (Mark an error if he pulls on oil buffer group before doing this.)
(9) Pulls out the oil buffer and barrel groups part way.
(10) Separates oil buffer and barrel groups.
(11) Removes barrel group from casing.

B. When he has performed these operations, tell him: "ASSEMBLE YOUR GUN, AND NOTIFY ME AS SOON AS YOU ARE FINISHED. NO ADJUSTMENTS WILL BE NECESSARY." Watch to see that he:

(12) Inserts barrel group part way into casing group and then locks the oil buffer group to the barrel extension. (Mark an error if he fails to check engagement of piston rod hook and barrel extension-shank hook by pulling on the oil buffer tube.)
(13) Replaces them in the gun with oil buffer group and barrel extension protruding. (Mark an error if he locks the oil buffer and barrel groups into the casing before replacing the bolt group in the barrel extension.)
(14) Replaces the bolt group in barrel extension.
(15) Replaces driving spring rod assembly in bolt group.
(16) Pushes recoiling parts forward until oil buffer body spring lock engages completely.
(17) Replaces bolt stud. (Mark an error if he uses driving spring rod assembly to position the bolt group.)
(18) Pushes the recoiling parts into battery position, using the bolt stud or charging handle. (Mark an error if he uses the driving spring rod assembly to accomplish this.)
Allow the guner to make the error of placing the bolt group in the casing with the cocking lever to the rear. If he does this, stop his time immediately and say to him: "YOU HAVE PLACED THE BOLT IN THE CASING WITH THE COCKING LEVER TO THE REAR. YOUR TIME IS STOPPED. REMOVE YOUR BLINDFOLD AND GLOVES AND TAKE OUT THE BOLT WITHHOUT ROTATING THE COCKING LEVER FORWARD." (Assistance may be given the gunner on these steps if necessary.)
When bolt is removed, check the position of firing pin extension notch and sear notch, to ascertain whether or not cocking lever was originally positioned properly. If the notches are not engaged, mark an error. If they are engaged, do not mark an error. Say to the gunner: "REPLACE YOUR BLINDFOLD AND GLOVES.

WHEN YOU ARE READY, LET ME KNOW, AND I WILL START YOUR TIME AGAIN."

(19) Engages driving spring rod retaining pin in the driving spring rod retaining pin recess.
(20) Replaces the backplate. (Mark an error if the backplate is not securely fastened.)
(21) Closes the cover.
(22) Hand-charges the gun.
(23) Releases the firing pin by depressing the trigger.

C. As soon as the gunner indicates that he is finished, record the time on the Score Sheet.

D. As soon as the guner has completed these operations (satisfactorily or not), remove his gloves and blindfold and go on to the detail strip.

7. Detail Strip

A. Tell the gunner: "YOU WILL NOW DETAIL STRIP THE GUN. STRIP EACH GROUP AS YOU REMOVE IT. DO NOT REMOVE THE COVER. ALL RIGHT, GO AHEAD." As he starts, put down the exact time in the proper space on the Score Sheet. Watch to see that he:

(24) Raises cover and checks feedway.
(25) Charges gun twice, making sure cover is closed. (Mark an error if cover is left up.)
(26) Make sure parts are in battery position before removing backplate.
(27) Removes the backplate. (Mark an error if he starts to disassemble the cover group first.)
(28) Removes the driving spring rod assembly completely from the bolt group. (Mark an error if he removes the bolt group from the casing before doing this.)
(29) Removes the bolt stud and removes the bolt group.
(30) Rotates cocking lever to the rear. (Mark an error if he depresses sear before doing this.)
(31) Releases firing pin by depressing sear.
(32) Removes extractor assembly.
(33) Removes the bolt switch.
(34) Removes bolt switch stud, if it can be removed by fingers.
(35) Removes cocking lever pin and cocking lever.
(36) Removes sear stop assembly.
(37) Removes sear slide.
(38) Removes sear and sear spring.
(39) Removes and separates the firing pin assembly.
(40) Depresses oil buffer body spring lock. (Mark an error if he pulls on oil buffer group before doing this.)
(41) Pulls out the oil buffer and barrel groups part way.
(42) Separates oil buffer and barrel groups.
(43) Starts to disassemble oil buffer group. (Mark an error if he starts to disassemble any other group first.)
(44) Removes the oil buffer tube. (Mark an error if he removes either the tube lock or accelerator before doing this.)
(45) Removes the oil buffer tube lock. (Mark an error if he removes the accelerator before doing this.)
(46) Removes the accelerator.
(47) Starts to disassemble the barrel group next. (Mark an error if he starts to disassemble any other group next.)
(48) Separates the barrel and barrel extension.
(49) Removes the breech lock.
(50) Starts to disassemble the cover group next. (Mark an error if he starts to disassemble the casing group next.)

(51) Removes the belt feed lever, preventing the spring from jumping.
(52) Removes the belt feed lever plunger and spring.
(53) Removes the belt feed slide assembly and disassembles it, preventing the spring from jumping. (Mark an error if he fails to perform either of these operations.)
(54) Removes cover latch spring.
(55) Removes cover extractor spring.
(56) Removes the belt-holding pawl pin, belt-holding pawl and springs, preventing the springs from jumping.
(57) Removes the cartridge stops and link stripper.
(58) Removes the trigger bar.

8. Assembly

A. When the gunner has performed all operations up to this point, first check to make sure that the gun is completely stripped, and then have him turn his back while you do the following things:

1. Mix up the disassembled parts thoroughly.
2. Substitute three broken parts for any good parts.
3. Turn the buffer adjusting screw so that it is too loose.

At any point during the assembling of the gun, but before he attempts to place these parts in their proper groups, require the gunner to report each broken part by its proper name and show what is broken. Make a record of the gunner's handling of the broken parts under items 113, 114 and 115. Give the gunner a good part to use in assembling the gun. If the gunner claims a good part is defective, mark an error. Blanks number 116, 117 and 118 have been provided in the last column. These blanks are there for this purpose only. DO NOT MARK AN ERROR FOR A FAILURE TO ASSEMBLE ANY PART OF A GROUP CORRECTLY, IF THE GUNNER CORRECTS THE ERROR BEFORE STARTING TO ASSEMBLE THE NEXT GROUP.

B. Tell the gunner: "YOU WILL NOW ASSEMBLE THE GUN. IN DOING SO, YOU ARE TO CHANGE THE DIRECTION OF FEED TO FEED FROM THE RIGHT" (or LEFT—specify direction of feed), "AND MAKE ALL NECESSARY ADJUSTMENTS. IN ADDITION, I HAVE PUT IN THREE PARTS THAT ARE BROKEN. YOU MUST FIND THESE BROKEN PARTS BEFORE YOU ACTUALLY PUT THEM IN THEIR PROPER PLACES IN THE GROUPS; HAND THEM TO ME AND NAME THEM. YOU MUST FOLLOW THE ORDER OF ASSEMBLY OF GROUPS TAUGHT IN THE WEAPONS COURSE. IS THIS CLEAR?"

(Repeat these directions, if necessary.)

"YOU WILL ASSEMBLE THE GUN BY GROUPS, AND AS YOU COMPLETE EACH GROUP YOU WILL REPLACE IT IN THE GUN. SORT OUT ALL PARTS BY GROUPS BEFORE YOU START."

Watch to see that he:

(59) Begins to assemble the casing group. (Mark an error if he begins to assemble any of the remaining groups first.)
(60) Replaces the trigger bar.

(61) Replaces the cartridge stops and line stripper on the correct side in their proper positions.
(62) Replaces the belt-holding pawl springs and belt-holding pawl on the correct side.
(63) Begins to assemble the cover group. (Mark an error if he begins to assemble any other group first.)
(64) Replaces the cover extractor spring.
(65) Replaces the cover latch spring.
(66) Joins belt feed pawl and pawl arm, with pawl arm on correct side.
(67) Replaces the belt feed pawl spring correctly, and replaces the belt feed pawl and pawl arm.
(68) Replaces the belt feed slide assembly in the correct position.
(69) Replaces the belt feed lever plunger and spring in the correct hole.
(70) Replaces the belt feed lever and cotter pin.
(71) Starts to assemble the barrel group next. (Mark an error if he starts to assemble any other group next.)
(72) Replaces the breech lock with the angles forward and the hole to the bottom.
(73) Without inserting the barrel into the casing, screws the barrel into the barrel extension until the breech end of the barrel is flush with the inside of the barrel extension.
(74) Puts bolt, without any of its parts assembled in it, on the barrel extension and slides it all the way forward.
(75) Holding the parts upside down, screws the barrel in as far as it will go. (Mark an error if he supports the barrel on a bench or anything but his hand.)

At this point check the headspace adjustment by turning the parts right side up and making sure the breech lock pin is toward the bolt and flush against the end of its slot in the barrel extension, and there is no back and forth movement of the belt while the breech lock is held in this position.

(76) Unscrews the barrel three notches. (He may support the barrel for this operation.)
(77) Turns the parts right side up and checks to see that the breech lock falls of its own weight. If the breech lock does not fall, checks for dirt or excess oil. Readjusts if necessary.
(78) Places barrel group part way into casing.
(79) Begins to assemble the oil buffer group next. (Mark an error if he begins to assemble any other group next.)
(80) Replaces the oil buffer tube in the oil buffer body. (Mark an error if he replaces either the oil buffer tube lock or the accelerator before doing this.)
(81) Replaces the oil buffer tube lock. (Mark an error if he replaces the accelerator before doing this.)
(82) Replaces the accelerator properly.
(83) Adjusts oil buffer tube correctly. (Mark an error if he does not turn exactly 3 clicks to the right of no clicks.)
(84) Locks the oil buffer group to the barrel extension. (Mark an error if he fails to check engagement of piston rod hook and barrel extension shank hook by pulling on the oil buffer tube.)
(85) Begins to assemble the bolt group, joins the firing pin to the firing pin extension, and replaces them with the notch facing down.
(86) Replaces the sear spring and sear. (Mark an error if he fails to seat the spring properly.)
(87) Replaces the sear slide.
(88) Replaces the sear stop assembly.
(89) Replaces the cocking lever with pregnant side forward, replaces the cocking lever pin on the side of the bolt.
(90) Checks firing mechanism by pivoting cocking lever forward and then backward and depressing sear. (Note: Leaves cocking lever to rear until he places bolt group in barrel extension.)
(91) Replaces the bolt switch stud if it has been removed.
(92) Replaces bolt switch for the correct direction of feed.

(93) Replaces the extractor assembly.
(94) Mark an error if he locks the barrel and oil buffer groups into the casing before replacing the assembled bolt group in the barrel extension.
(95) Replaces the bolt in barrel extension. (Mark an error if he pushes recoiling parts into battery position.)
(96) Replaces the driving spring rod assembly in bolt group.
(97) Pushes recoiling parts forward until oil buffer body spring lock engages completely.
(98) Replaces bolt stud. (Mark an error if he uses driving spring rod assembly to position the bolt group.)
(99) Pushes the recoiling parts into battery position, using the bolt stud or charging handle. (Mark an error if he uses the driving spring rod assembly to accomplish this.)

Allow the gunner to make the error of placing the bolt group in the casing with the cocking lever to the rear. If he does this, stop his time immediately and say to him: "YOU HAVE PLACED THE BOLT IN THE CASING WITH THE COCKING LEVER TO THE REAR. YOUR TIME IS STOPPED. TAKE OUT THE BOLT WITHOUT ROTATING THE COCKING LEVER FORWARD." (Assistance may be given the gunner on these steps if necessary.) When bolt is removed, check the position of firing pin extension notch and sear notch, to ascertain whether or not cocking lever was originally positioned properly. If the notches are not engaged, mark an error. If they are engaged, do not mark an error. Say to the gunner: "WHEN YOU ARE READY, LET ME KNOW, AND I WILL START YOUR TIME AGAIN."

(100) Engages driving spring rod retaining pin in the driving spring rod retaining pin recess.
(101) Replaces the backplate. (Mark an error if the backplate is not securely fastened.)
(102) Adjust buffer adjusting screw. (It should be as tight as possible using a caliber .50 combination wrench, and should be from flush to one thread protruding.)
(103) Closes the cover.
(104) Hand-charges the gun.
(105) Releases the firing pin by depressing the trigger.

C. As soon as the gunner finishes item No. 105, put down the time.

(106) Checks headspace with headspace gage. (Mark an error if he does not use the gage correctly.)
(107) Makes adjustments if necessary.

D. Throw off the headspace by unscrewing the barrel a few notches. Tell him: "NOW ADJUST HEADSPACE AGAIN WITH THE GUN FULLY ASSEMBLED."

E. Watch to see that he:

(108) Screws the barrel in until the parts no longer return to battery without being forced. (Mark an error if he fails to do this.)
(109) Unscrews the barrel one notch at a time until the recoiling parts go into battery when he pulls the bolt back 1 inch and lets it go. (Mark an error if a right-hand rear cartridge stop is mounted on the gun and the gunner does not remove it.)

(110) Unscrews the barrel two more notches. (Mark an error if he does not unscrew it exactly two notches.)
(111) Checks adjustment with the headspace gage.

F. Say to the gunner: "CHECK THE TIMING."

G. Watch to see that he:

(112) Checks timing with the timing gage. (Mark an error if he does not use the gage properly.)

H. Record the total number of errors on the phase check as soon as the phase check is completed.

I. At whatever point in the assembling of the gun the gunner discovers a broken part, record the fact that he was correct or made an error in spaces 113, 114 and 115 on the Score Sheet. Also record the name of the broken part on the Score Sheet on the line called "Defective Parts." If the gunner claims good parts are defective, mark an error in blanks 116, 117 and 118 and record name of part under "Description of Errors."

(113) Check to see that he discovers and correctly identifies one of the defective parts.
(114) Check to see that he discovers and correctly identifies another of the defective parts.
(115) Check to see that he discovers and correctly identifies the third defective part. (Mark an error if the guner fails to discover a defective part.)
(116) Record an error if the gunner claims that a good part is defective.
(117) Record an error if the gunner claims that a good part is defective.
(118) Record an error if the gunner claims that a good part is defective.

LIST OF FLEXIBLE GUNNERY PHASE CHECKS AND RELATED MATERIALS

1. Blue Series, April 1944, Prepared by AAF Instructors School, Flexible Gunnery, in Collaboration with AAF Training Aids Division.

Stripping and Assembly of Caliber .50 Machine Gun.
Care and Cleaning of Caliber .50 Machine Gun.
Malfunctions of the Caliber .50 Machine Gun.
Boresighting of the Caliber .50 Machine Gun.
Maintenance and Operation of Bendix Chin Turret.
Maintenance and Operation of Sperry Upper Turret.
Maintenance and Operation of Sperry Lower Ball Turret.
Maintenance and Operation of Emerson Nose Turret.
Maintenance and Operation of Martin Upper Turret.
Maintenance and Operation of Consolidated Tail Turret.
Maintenance and Operation of Bendix Upper Turret.

2. Green Series, July 1944, Prepared and Mimeographed by Central School for Flexible Gunnery.

Stripping and Assembly of Caliber .50 Machine Gun, Form B.
Harmonization of Caliber .50 Machine Gun.
E-14 Trainer.

3. Red Series, November 1944, Prepared by Central School for Flexible Gunnery, in Collaboration with AAF Training Aids Division.

Caliber .50 Machine Gun, Stripping and Assembly (Form B).
Caliber .50 Machine Gun, Care and Cleaning Form B).
Caliber .50 Machine Gun, Stripping and Assembly, Preventive Maintenance, Mounting of Adaptors and Heaters (Form C).
Caliber .50 Machine Gun, Harmonization (Form B).
Martin Upper Turret (Form B).
Emerson Nose Turret (Form B).
Consolidated and Motor Products Tail (Form B).
Sperry Lower Ball Retractable (Form B).
Sperry Lower Ball Non-Retractable (Form B).
Bendix Chin (Form B).
Bendix Upper Turret (Form B).
Sperry Upper Turret (Form B).
Bell Gun Mount Assembly (Form A).
E-14 Trainer (Form A).
A-26 Sighting Station.
A-26 Upper Turret.
A-26 Lower Turret.

4. Blue Series, May 1945, Prepared and Mimeographed by Central School for Flexible Gunnery.

P-61 Sighting Station.
P-61 Turret.

5. Black and White Series, Aerial Gunner's Proficiency Check Series, Prepared and Mimeographed by Central School for Flexible Gunnery.

B-24 Aerial Gunner's Proficiency Check.
B-29 Aerial Gunner's Proficiency Check.
B-32 Aerial Gunner's Proficiency Check.

6. Aside from the above phase checks, which in each case included booklets of administration and score sheets, the following additional material was prepared to facilitate the adequate training of phase checkers.

1. *AAF Manual 55, The Use of Flexible Gunnery Phase Checks.*
2. *Training Film, TF 1-3464 "Administration of Standardized Phase Checks."*

Yes. The curriculum, which includes a great deal of practical work, provides the gunner with the opportunity for putting into actual use much of what he has learned.

6. *Does the program provide for the assembly and drawing together of skills acquired and knowledge gained in different courses?*

Yes, this is provided in progress checks, in preflighting and postflighting of equipment, in application of skills and knowledge on trainers and ranges, and in air training. It is suggested that prior to graduation an orientation period be provided to evaluate the gunner's basic training and prepare him for crew training.

Logic of Phases

7. *Does each step make a definite contribution to proficiency?*

A good logical case can be made for every phase of training. Over a period of time most nonrelated phases have been dropped out. Some questions still exist, however, as to the value of certain phases (e.g. shotgun firing).

8. *Is an effective orientation period provided for in each course?*

Yes. One criticism might be made of some of the orientation. It too often stresses details of procedure at the expense of arousing student interest. The possibility of more thoroughly planned orientation at the beginning of the training period should be considered. This would not necessarily do away with specific course orientation but would reduce the time devoted to each, and knit all courses into one whole.

9. *Are devices provided to aid instructors in arousing and maintaining interests?*

Some are, such as the use of cut-away models of the gun and the Gunner's Information File. Consideration should be given to the development of instructors' manuals which would serve the same purpose for methodology and G.I.F. serves for factual information.

Learning by Doing

10. *Is actual doing stressed wherever possible in the training program?*

Yes. The gunnery program provides a maximum of training by actual doing, within the limitations of facilities available.

11. *What specific methods are used to insure attention during lectures, films, demonstrations, and while students are waiting to use equipment?*

To a great extent students are so directed that the type of activity results out of which learning takes place. They are encouraged to take notes, answer questions, and engage in dis-

armorers who have a good background in both Weapons and Turrets.

19. *Are complicated skills developed step by step?*

In the main, yes. The classroom work which precedes ranges and trainers is designed to give the gunner an understanding of what to do. Ranges and trainers give him practice in how to do it. Gun camera and air firing relate the "what" to the "how" and give training which simulates the job of the aerial gunner in combat. It is possible that some students are overwhelmed by the mass of technical information in such classes as Turrets. In the case of ranges, it was discovered desirable habits formed on some ranges are undesirable on others. An example Instructors felt that instruction on this range should precede that on the Burst Control Range, because as a result of his experience on the latter range, the gunner had developed the habit of pushing up on the rear of his gun, a habit that was undesirable on the Moving Base Range. This sort of conflict tends to impede rather than to enhance gunnery learning. The elimination of confusion in learning should be a "must" in nay type of educational program.

20. *Is group instruction used for material which can be most efficiently mastered this way?*

Yes. In subjects such as Weapons, Sighting, and Turrets there is good balance between group instruction for the bulk of learning and individual instruction wher eneeded to bring each student up to standard, and to provide for individual differences.

21. *Is adequate time allotted for the accomplishment of each training objective?*

The distribution fo time to courses in the 8-week program appears to be adequate in terms of the limited training objectives to be achieved and the training facilities presently available.

Sequence of Training

22. *Does the student have adequate previous training before beginning each advanced range or trainer?*

This question can best be answered by reference to instructor's comments on the question "what weaknesses, if any, in the previous gunnery training of your students interfered with their learning of the material you taught?" The weaknesses in previous training which are reported by the instructors, however, must be interpreted in light of two considerations: First, the instructors may be setting to ohigh a standard; and second, the difficulties experienced by students may result not from a lack of previous training, but from the inability to adjust to the peculiarities of a new situation.

Index of Names

Subject Index

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